THE
BRITISH ENCYCLOPAEDIA
OF
MEDICAL PRACTICE

VOLUME 2

SIR HUMPHRY ROLLESTON

WITH ASSISTANCE OF

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THE
BRITISH ENCYCLOPAEDIA OF MEDICAL PRACTICE

INCLUDING

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ACKNOWLEDGEMENTS

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APRAXIA

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Reference may also be made to the following titles:

APHASIA
BRAIN: REGIONAL DIAGNOSIS
BRAIN TUMOURS
BRAIN: VASCULAR DISORDERS

1.–DEFINITION OF TYPES OF APRAXIA

76.] Apraxia may be defined as an inability to perform purposive movements, without any impairment of mobility, co-ordination or sensation.

In cases of intracranial tumour or cerebrovascular disease, it is not rare to find that the patients' movements are peculiarly clumsy and maladroit. Although not paralysed, they may be unable to dress themselves or to handle correctly a knife or fork, toothbrush, comb or razor; in the same way, they cannot readily carry out any simple command, and fail to touch the nose, make a fist or wave the arm when requested. One may be tempted, at first glance, to attribute these defects to a mere lack of understanding of the command given, or to a non-recognition of the object placed in the hand. This may be far from the correct explanation, however, and the lack of response may exist in spite of a complete comprehension of what is required.

Hughlings Jackson was the first to describe an apraxic phenomenon, when under the term 'imperception' he alluded to the common inability of a hemiplegic to protrude the tongue on command. That the failure is due to an 'apraxia' of the tongue rather than a paralysis is shown by the fact that the patient is perfectly able to moisten the lips, or to lick a postage-stamp.

During the last seventy-five years a confusing terminology has grown up around the subject of apraxia, but in this article the very simplest classification will be adopted.

We may recognize, in the most general terms, two main clinical varieties—namely, motor apraxia and ideational apraxia. At the bedside, it is naturally far from easy to distinguish between them, especially if a speech disorder is also present.

Motor apraxia

In the former variety (motor apraxia) we are dealing with a defective transmission between the mental idea of the desired movement and its correct execution. The patient knows what he wants to do but seems unable to make his limbs obey his will. Thus, shown a pencil, he may recognize it as such and realize its use, but fail absolutely to grasp or handle it properly; he may even act as though it were a toothbrush or a cigar. Or the patient, requested to shake his fist at the examiner, may execute hesitant and aimless gestures in the air, although fully cognizant of what is required of him. Motor aphasia is of course merely a specialized clinical type of motor apraxia, just as apraxia of the upper limbs might be regarded as an 'aphasia of the extremities'.

Ideational apraxia

Should the patient fail to recognize the nature of the object given him, the resulting motor defect is known as ideational apraxia. Similarly, if the patient when told to make a fist fails to do so because he has no clear conception of what he is supposed to do with his hands, he is again exhibiting an ideational apraxia. It is obvious that this ideational apraxia belongs to an entirely different order of defect from that of the motor variety, and that it is in reality merely a part of an agnosia or defective understanding of symbols. Strictly speaking, the ideational type is not an apraxia at all.

Within more recent times, Kleist has added another clinical variety which he has termed 'constructive apraxia'. Patients manifesting this condition 'may be able to perform all purposeful activities in daily life, but they fail or find difficulty in making simple patterns with mosaics, matches, bricks, in copying drawings and sometimes in writing—in short, in all constructive tasks'. Mayer-Gross has interpreted constructive apraxia as the expression of some degree of space-impairment, using Grünbaum's conception of 'personal space' (*Eigenraum*) as contrasted with 'outer space' (*Fremdraum*). In the automatic activities of normal healthy adults there is no distinction between 'personal' and 'outer' space; but in persons with constructive apraxia the fundamental difficulty, according to Lange, is in 'changing the hand from a part of the body in "personal space" into a tool or object in the service of the personality in "outer space"'.

he relation f apraxia o aphasia

It has already been stated that motor aphasia is a special form of apraxia, but apraxia of the limbs is not invariably associated with motor aphasia, and vice versa. But, like motor aphasia, apraxia is commonest in lesions of the left hemisphere, and may be present in the left arm in association with a right hemiplegia.

Apraxia may also be seen in association with the phenomenon known as 'forced grasping' (see p. 4).

2.–CLINICAL PICTURE OF ALL TYPES

Clinical examination

As apraxia may be present not only in the upper limbs, where it is most easily recognized, but also in the facial or bulbar group of muscles, the legs or the trunk, examination must necessarily be thorough.

The patient is instructed to protrude the tongue, screw up the eyelids and show the teeth; failure to perform these movements on command will raise the suspicion of an apraxia, if they are subsequently performed automatically or in response to a reflex stimulus. Thus an apraxic patient may be unable to screw up the eyelids when requested but will do so involuntarily when exposed to a draught or to the fumes of a cigarette.

Coriat's instructions as to the mode of testing for apraxia in the upper limbs may be quoted verbatim: 'Each hand should be tested separately for reactions to requests, such as snapping the fingers, touching the nose or ears, making a fist or for certain imaginary movements without the use of objects, such as the movements of cutting with a scissors, turning a key in the lock, combing the hair, shaving, etc. Then one should proceed to reactions of the use of objects with each hand separately, such as the use of a comb, toothbrush, pen, match, key, spoon, lighting a cigar, etc. While these reactions are being tested, we should carefully observe the patient for any of the peculiar behaviour already indicated—for instance, substitution of movements, monotonous repetition or curtailed reactions. All of the above tests should then be repeated with the eyes closed in order to determine if there be any increase of the apraxic disturbance under these conditions. . . .

'From a number of dissimilar objects spread upon the table, several should be selected with each hand separately, in order to eliminate any defective recognition of objects. Imitation of movements should be carefully tested for, and with each limb separately. The presence or absence of sensory or motor aphasia, agraphia, ataxia and word deafness should be carefully determined.'

In addition to these foregoing tests described by Coriat, a close but unobtrusive observation should be made of the patient's behaviour during the execution of more automatic activities. Thus the manner in which the patient feeds himself, dresses, washes, gets in and out of bed, may betray eloquently apraxic disorders of the limbs and trunk.

Types of error

Just as the disorders of speech uttered by an aphasic patient are capable of some classification, so also one can analyse the motility-defects of an apraxic subject. In the first place, the patient may substitute another movement for the one demanded, i.e. touch his ear instead of his nose (parapraxia or parakinesis). Or a movement may be initiated correctly but never completed (curtailed reaction). At times one or more components may be omitted from a complex movement, a defect known as short-circuiting. When complex pseudo-spontaneous movements replace the normal manipulation of objects, we may speak of formless or amorphous reactions. Repetitions of a movement are frequently seen (palipraxia or clonic perseveration), or the patient may aimlessly imitate the actions of other people (echopraxia). Tonic perseveration is the term applied to that variety of curtailed reaction in which the limb is suddenly and spontaneously checked in a catatonic, antigravity posture. Analogous to the restricted vocabulary of the aphasic subject, we find a widespread poverty of movement, or hypokinesis, in an apraxic patient.

What may be vaguely termed 'contrary actions' are not rare in apraxic subjects. These include the so-called *counterpull* in which the patient will try to close the fist when the examiner tries to extend the fingers, to flex the elbow when the examiner tries to straighten the joint, and so on.

An interesting series of motility-defects has been described by Mayer-Gross. The author speaks of a 'fear of empty space', applying this term to the condition wherein, for instance, the hands in activity avoid loneliness, as it were, and seek the company of other objects. Thus, in rhythmic movements or in gymnastic exercises, the hands tend to approximate, either to each other, or to external objects, or to the hands of the examining doctor. Mayer-Gross calls this the 'closing-in' symptom.

ssociated otility-isorders

Besides these phenomena which constitute an essential feature of the apraxic syndrome, various other psychomotor and psychosensory defects are not uncommonly associated. Aphasias of all types may be included here. Forced grasping and groping are often present, either on one side or on both. Visual and auditory agnosias can sometimes be detected.

3.–MORBID ANATOMY

Apraxia, like aphasia, may arise in association with diffuse affections of the cerebral hemispheres (toxic or delirious states, senile degenerations, encephalitides) but more commonly as the result of focal lesions of the brain (cerebrovascular affections, tumours).

Although the correlation of apraxic manifestations with circumscribed areas of cerebral disease is not yet precisely determined, we may say that lesions of the left supramarginal gyrus and its immediate subcortex are frequently associated with a bilateral apraxia. This region has indeed been identified with a hypothetical 'eupraxic centre'. From this 'centre' fibres lead forward to the motor cortex of the same hemisphere and also, after crossing by way of the corpus callosum, to the contralateral motor area. It follows therefore that a lesion of the corpus callosum may be followed by a left-sided apraxia, on account of a removal of 'eupraxic' impulses from the motor cortex of the right hemisphere. Similarly a right-handed apraxia would theoretically follow a subcortical lesion severing the fibre-connexions between the left supramarginal gyrus and the motor area of the same side.

Unequivocal data as to the pathological anatomy of the various types of apraxia, i.e. ideational as opposed to motor, are still lacking.

4.–DIAGNOSIS

Recognition of an apraxic disorder is not difficult when the patient is of normal mental calibre and when little or no aphasia co-exists. One must remember, however, that the apraxia may be masked by a certain degree of motor weakness which, on superficial examination, obtrudes itself as the more obvious defect.

In the case of a demented subject, it may be a matter of considerable difficulty to decide whether the motility-disorder is one of apraxia, or merely due to impairment of cerebration. Strictly speaking, the bilateral psychomotor disorders of the demented are actually phenomena of an agnostic, i.e. an ideational order. When, however, the motility-defect is confined to the limbs of one-half of the body, one is obviously dealing with phenomena of a focal character, and hence with an apraxia.

The combination of a mixed type of aphasia with a bilateral apraxia presents the commonest and at the same time one of the most difficult clinical problems. As already described under APHASIA (Vol. I., p. 701) it may be far from easy to decide whether failure to execute a simple request is due to a defective comprehension of the command (sensory aphasia) or to an impaired kinaesthetic schema (ideational apraxia) or to a failure to translate thought into action (motor apraxia).

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ARACHNODACTYLY

See BONE DISEASES, p. 557

ARGYLL ROBERTSON PUPIL

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2. PSEUDO ARGYLL ROBERTSON PUPIL - - 7

efinition 77.] A small pupil, in an eye with good vision, which reacts normally during the act of accommodation-convergence, but does not contract at all when light is thrown on the eye, and dilates only partially under the action of atropine.

etiology Such a pupil is almost invariably due to syphilis of the central nervous system. In rare instances a similar condition of one pupil may occur after herpes ophthalmicus or during recovery from injuries affecting the oculomotor nerve.

It must, however, be emphasized that pupils which have lost their reaction to light and retained their reaction with accommodation-convergence, but which do not fulfil the other requirements of the definition given here, may result from many different causes.

1.—TRUE ARGYLL ROBERTSON PUPIL

escription The Argyll Robertson pupil is seen most frequently and characteristically in tabes dorsalis. The phenomenon is ordinarily bilateral, but there are very often differences in size between the two pupils and in a large proportion of cases the pupils are irregular in outline. Atrophic changes in the irides are usually apparent. The distribution of pigment becomes irregular and the pigment gradually disappears from parts of the iris, the sclera behind causing the deprived parts to have a light-blue appearance. Sometimes a ring of pigment remains close to the pupil. Gowers attributed the small size of the pupil to hypotonia of the radial fibres of the iris, and the same explanation may account for the incomplete dilatation of the pupil when atropine is instilled into the eye.

With the true Argyll Robertson pupil the reaction during accommodation-convergence is normally brisk; this distinguishes it from the myotonic or pseudo Argyll Robertson pupil (see p. 7) and from fixed and incompletely fixed pupils, none of which have the same significance as the true Argyll Robertson pupil.

Mechanism

The afferent fibres of the light-reflex arc pass back with the visual fibres in the optic nerve and optic tracts, but, whereas the visual fibres end in the lateral geniculate body, the fibres which serve the light reflex pass on to enter the superior corpus quadrigeminum. From there a connexion is formed by another fibre with the upper part of the oculomotor nucleus (Edinger-Westphal nucleus). The efferent fibres of the reflex arc form part of the oculomotor nerve. Since with the Argyll Robertson phenomenon vision is good, the visual path is evidently intact, and since the pupil contracts with accommodation-convergence, the cells and fibres of the third cranial nerve which innervate contraction of the pupil must be intact; the arc must therefore be interrupted in its middle portion, i.e. between the place where the light-reflex fibres leave the visual fibres, and the oculomotor nucleus. Degeneration of the fibres forming this middle portion of the arc is not, however, easy to recognize by staining methods and this theory still awaits anatomical confirmation.

The Argyll Robertson pupil, once established, persists in spite of anti-syphilitic treatment. As the tabetic process advances, the accommodation-convergence reaction may gradually be lost; and the pupil thus ceases to show the dissociation of reactions typical of the Argyll Robertson phenomenon, and becomes a fixed pupil.

Clinical variations

Modifications of the Argyll Robertson pupil are frequently encountered in diseases of the nervous system. A slight reaction to light may be present in a pupil which otherwise conforms to Argyll Robertson's description. This represents a preliminary stage of the complete phenomenon and its significance is similar.

Non-syphiliti varieties

More frequently the pupil reacts normally with convergence and does not react to light, but it is not small and may even be dilated. Such a pupil is common in central nervous syphilis, but has not the diagnostic significance of the complete Argyll Robertson phenomenon, for it may be due to any lesion interrupting the light reflex arc in its middle portion. A pineal tumour, for instance, or a tuberculoma or a patch of disseminated sclerosis may cause this abnormality, and it has been described in association with many different nervous diseases. If, however, atrophic changes are present in the iris, the condition is likely to be syphilitic.

The opposite dissociation of the pupillary reactions, i.e. loss of the accommodation-convergence reaction with preservation of the light reflex, is frequently seen in the Parkinsonian state which follows encephalitis lethargica.

2.–PSEUDO ARGYLL ROBERTSON PUPIL

Pseudo Argyll Robertson pupil (Foster Moore) or myotonic pupil (Adie) is a non-syphilitic abnormal condition of the pupil in which the *efinition* reactions are all slow, but the light reaction much slower than the convergence reaction. The pupil is of ordinary size or somewhat larger and is usually bigger than the unaffected pupil of the other eye. No reaction is obtained to the light of a torch shone on the eye, but if the patient sits for 10 or 15 minutes in a bright diffuse light the pupil gradually contracts, and if he sits in a dark room it dilates slowly. During accommodation-convergence, contraction of the pupil takes place slowly and continues through an abnormal range of movement, so that as convergence is maintained, the myotonic pupil finally becomes smaller than its fellow. After relaxation of convergence the pupil takes many minutes to dilate to its former size. In pupils of this kind prompt and full dilatation occurs with mydriatics.

The phenomenon is usually unilateral and the iris of the affected eye does not show degenerative changes, such as usually accompany the true Argyll Robertson pupil. Accommodation may be involved in the disturbance and then the patient complains of inability to focus with the affected eye.

etiology The cause of this phenomenon is unknown. It is the more likely to be mistaken for a syphilitic abnormality because in some cases it is associated with absence of some of the tendon-jerks in the limbs. Once established it persists, but as far as is known at present it is not associated with any progressive disease.

The differences between the true and the pseudo Argyll Robertson pupils may be tabulated as follows:

TRUE ARGYLL ROBERTSON PUPIL	PSEUDO ARGYLL ROBERTSON PUPIL
Quite inactive to light or darkness	Reacts slowly to light and darkness
Reacts briskly with convergence	Reacts slowly with convergence
Smaller than normal	Larger than normal
Ordinarily bilateral	Usually unilateral.
Usually irregular in outline	Regular in outline
Iris shows atrophic changes	Iris looks healthy
Dilates imperfectly with mydriatics	Dilates fully with mydriatics

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ARGYRIA

See Bronzing of the Skin, p. 713

ARRHYTHMIA

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Reference may also be made to the following title:

HEART DISEASES

1.–THE NORMAL CARDIAC CYCLE

78.] The recognition and classification of cardiac arrhythmias are comparatively recent developments in clinical medicine. An analysis of an abnormal rhythm of the heart depends on ascertaining the behaviour of both the auricles and ventricles during the period of irregularity. The ordinary methods of bedside examination reveal only the behaviour of the left ventricle, although some knowledge of the action of the right auricle can be ascertained by observation of the veins at the root of the neck.

Graphic records

The advent of the ink polygraph and later of the electrocardiograph made possible a simultaneous record of both auricular and ventricular contraction. By these methods cardiac arrhythmia has been the subject of much clinical and experimental investigation during the past thirty years. Step by step the various types of arrhythmia have been elucidated, and to some extent the normal and abnormal physiology of the heart mechanism has been explained. During the early days of investigation graphic records were essential to the interpretation of the various irregularities, but the knowledge gained by these methods now enables the clinician to recognize individual arrhythmias without their aid.

An analysis of symptoms, and the simpler methods of cardiovascular investigation by eyes, hands, and stethoscope are now usually sufficient for the diagnosis of most of the varieties of cardiac arrhythmia. Graphic methods have demonstrated the abnormal mechanisms underlying irregularities of the heart.

The cardiac cycle

The physiological and anatomical basis of the normal sequence of events in the cardiac cycle must now be briefly stated. There is much experimental and other evidence that the normal beat of the heart is generated in the sino-auricular node, a neuromuscular structure situated in the right auricle near the opening of the superior vena cava. A stimulus originates in that structure by means of some physico-chemical process, and this occurs regularly at a rate of approximately *undle of His*

seventy times per minute. Each regularly occurring stimulus excites a wave of contraction which spreads over the auricular musculature and produces auricular systole. This wave of excitation in its turn reaches the auriculo-ventricular node situated in the floor of the coronary sinus, and the stimulus is passed over to the ventricles by way of the main bundle of His and its right and left branches to both ventricles.

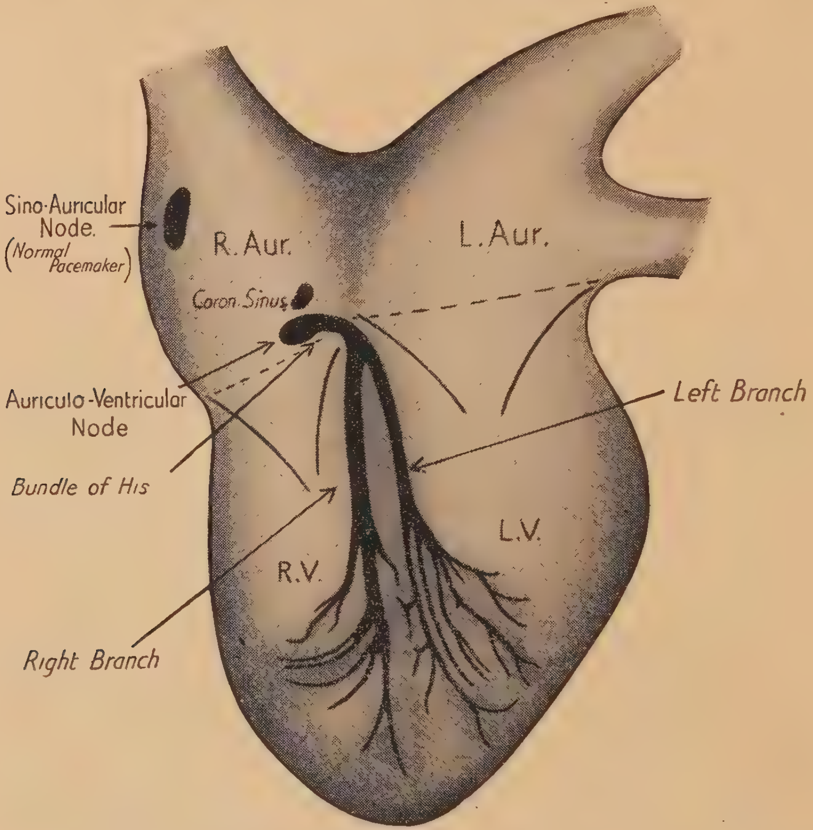
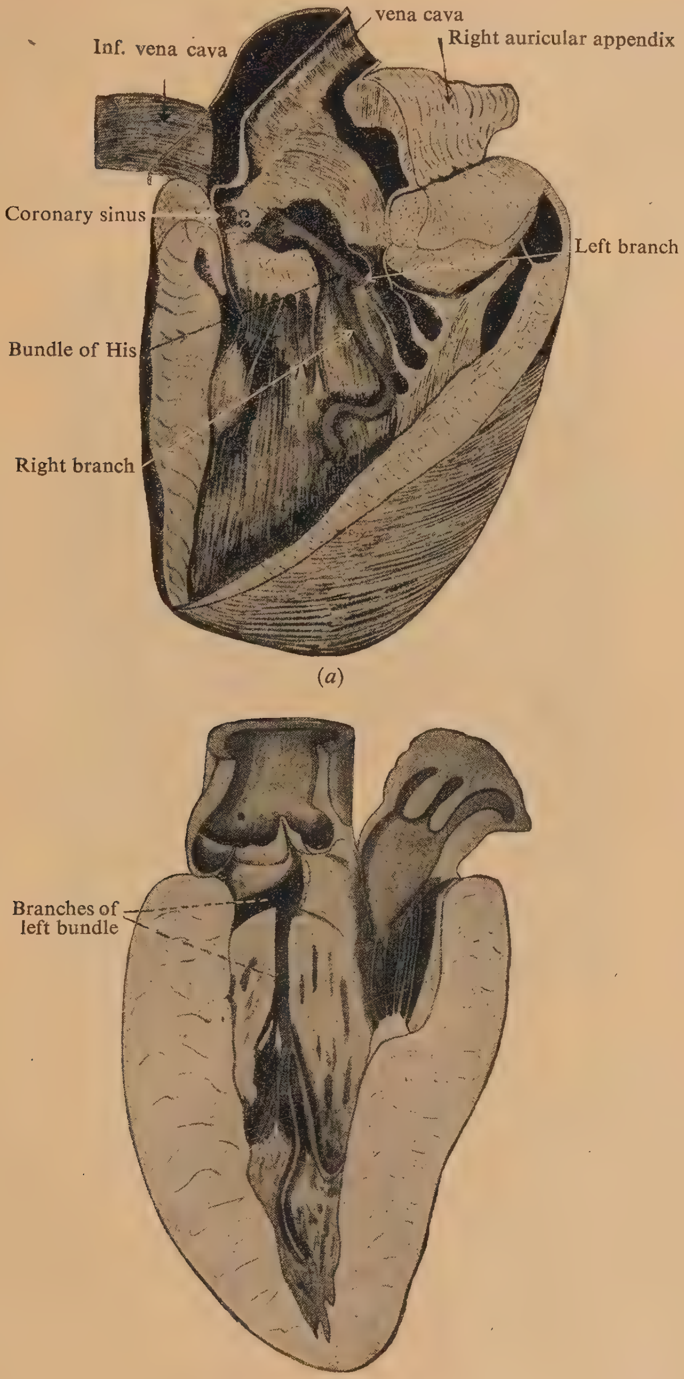


FIG. 1.—Diagram of bundle of His emanating from auriculo-ventricular node and innervating both ventricles through right and left branches

There is no other muscular connexion between auricles and ventricles except by way of this specialized neuromuscular tissue.

ino-
uricular
ode

Fig. 1 shows this connexion diagrammatically. The rhythm can only be regarded as completely normal when the heart-beat follows these paths, and it is only under such circumstances that a normal electrocardiogram is obtained. Fig. 2 shows the auriculo-ventricular node, bundle of His and both branches in a calf's heart. Figs. 3 to 5 show these structures in the human heart; and the sino-auricular node, situated in the sulcus terminalis of the right auricle at the junction of the superior vena cava and the free border of the right auricular appendix, is illustrated in Fig. 3. This node is composed of a plexiform



(a)

(b)

FIG. 2.—(a) Auriculo-ventricular node and bundle of His in a calf's heart
(b) Bundle of His with right and left branches in a calf's heart
(From *Further Advances in Physiology*, by Leonard Hill)

arrangement of fine muscular fibres which differ from ordinary heart muscle fibres in being thin and longitudinally striated and in having different staining properties. Interspersed among the network of fibres, which is very vascular, are numerous nerve-cells and nerve-fibres of both the vagal and sympathetic systems.

Auriculo-ventricular node

The auriculo-ventricular node is situated at the posterior and right border of the interauricular septum in the floor of the mouth of the coronary sinus. In the photomicrographs (Figs. 4 and 5), the extension of the main bundle through the auriculo-ventricular septum, and its final distribution by way of two branches (R and L) to the right and left ventricles, can be followed. The ultimate connexion between the terminations of the two branches and the general ventricular musculature is by an arborization somewhat similar to the Purkinje system in lower animals.

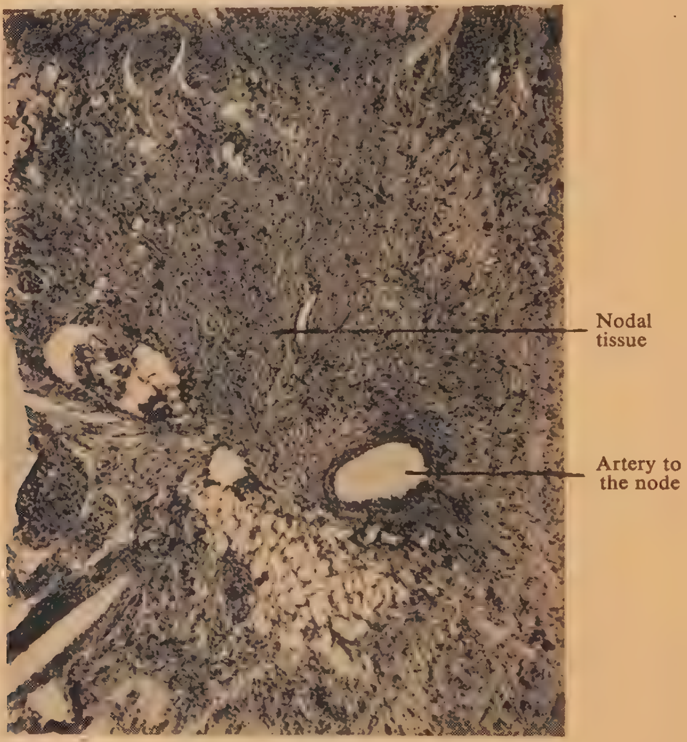


FIG. 3.—The sino-auricular (Keith-Flack) node. (× 90 diam.)

When the stimulus originates in the sino-auricular node and when the above pathways are followed, without let or hindrance, a normal electrocardiogram is obtained.

Normal electrocardiogram

Electrocardiograms are obtained by connecting the limbs with a string galvanometer, and in this connexion three leads are in common use:

lead I in which the right and left arms are connected, lead II in which the right arm and left leg are connected, and lead III in which the left arm and left leg are connected. In the various leads slight variations of the main auricular and ventricular complexes occur. In Fig. 6 auricular activity is represented by the upright P in all three leads. The beginning of ventricular activity is represented by the sharp R, which in the normal electrocardiogram is upright and continued into S in a downward direction, and the end of the ventricular systole is represented by T.

2.–SINUS ARRHYTHMIA

Clinical description

79.] This irregularity of the heart has no pathological significance; in fact it is usual in children and young healthy adults. When listening to the heart, or with the finger on the radial pulse, it will be found that the rate tends to wax and wane, the waxing and waning being intensified by breathing deeply. It will also be observed that this varying rate is broadly associated with the inspiratory and expiratory phases of respiration. Fig. 7 shows that the heart-rate quickens during inspiration and slows during expiration. The inspiratory phase is associated with a lowering of intrathoracic pressure, and usually increases the speed of the heart; but in some instances of sinus arrhythmia the varying speed is not so exactly related to the phases of respiration. Sinus arrhythmia is most obvious in slowly acting hearts and is indicative of increase of vagal tone and has not any pathological significance; quickening of the heart tends to do away with it.

3.–EXTRASYSTOLE

(1)—Definition and Mechanism

Synonyms

80.] The extrasystole is also called the premature beat, or ectopic beat, or bigeminal pulse. In this form of cardiac arrhythmia some focus other than the normal pacemaker (the sino-auricular node) initiates a wave of excitation and contraction. As this focus may be in either auricles or ventricles, both auricular and ventricular types are recognized; and a focus midway between auricles and ventricles (nodal extrasystole) is less common.

The mechanism of extrasystoles is illustrated in Figs. 8, 9 and 10.

(2)—Auricular Extrasystole

In Fig. 8 the fourth cardiac cycle in lead I is premature, because the auricles have contracted prematurely and have been followed by a

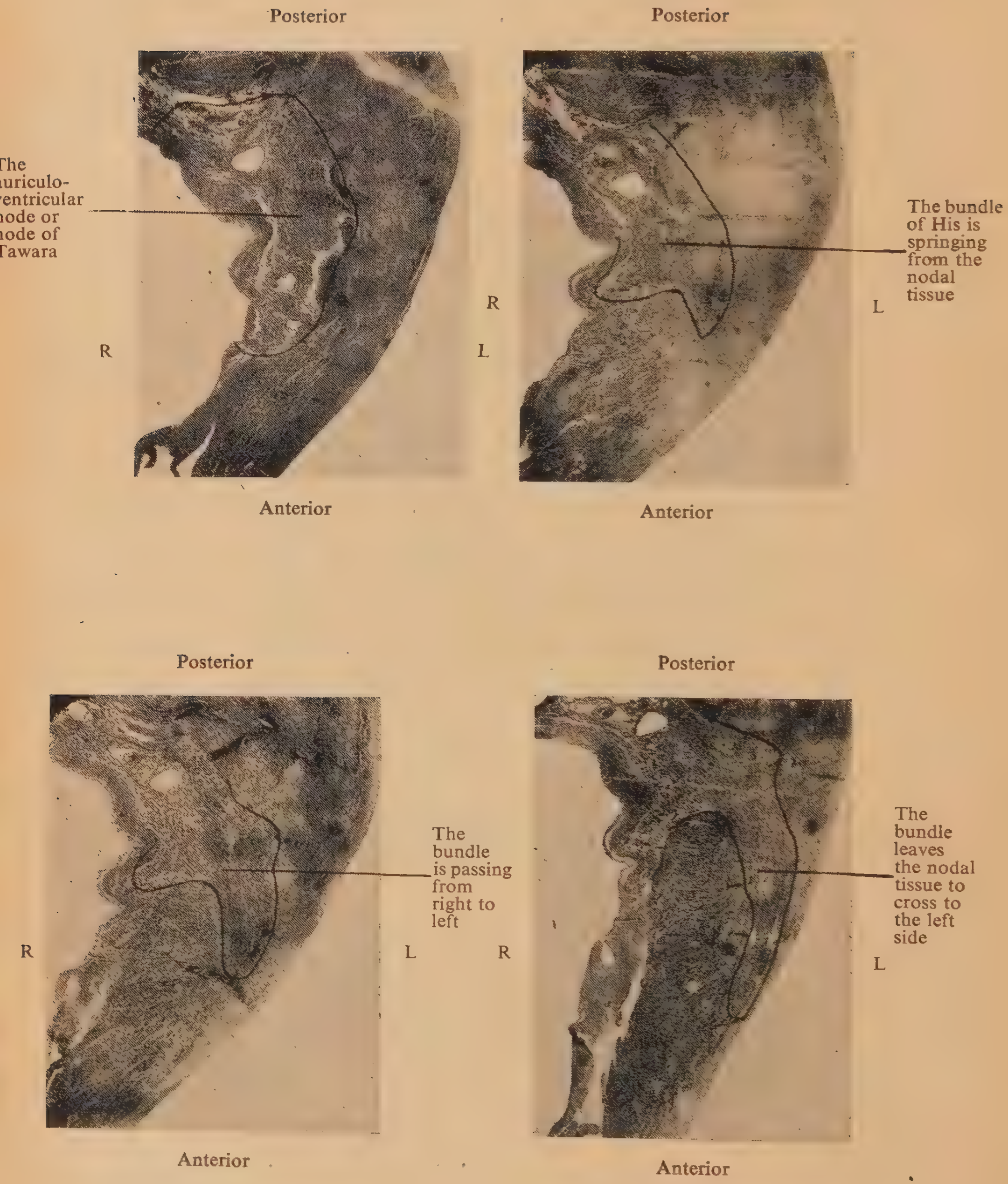

Posterior
The
uriculo-
entricular
ode or
ode of
Tawara
R
L
Anterior
Posterior
R
The bundle of His is springing from the nodal tissue
L
Anterior
Posterior
R
The bundle is passing from right to left
L
Anterior
Posterior
R
The bundle leaves the nodal tissue to cross to the left side
L
Anterior

FIG. 4.—Auriculo-ventricular node and bundle of His. (×18 diam.)

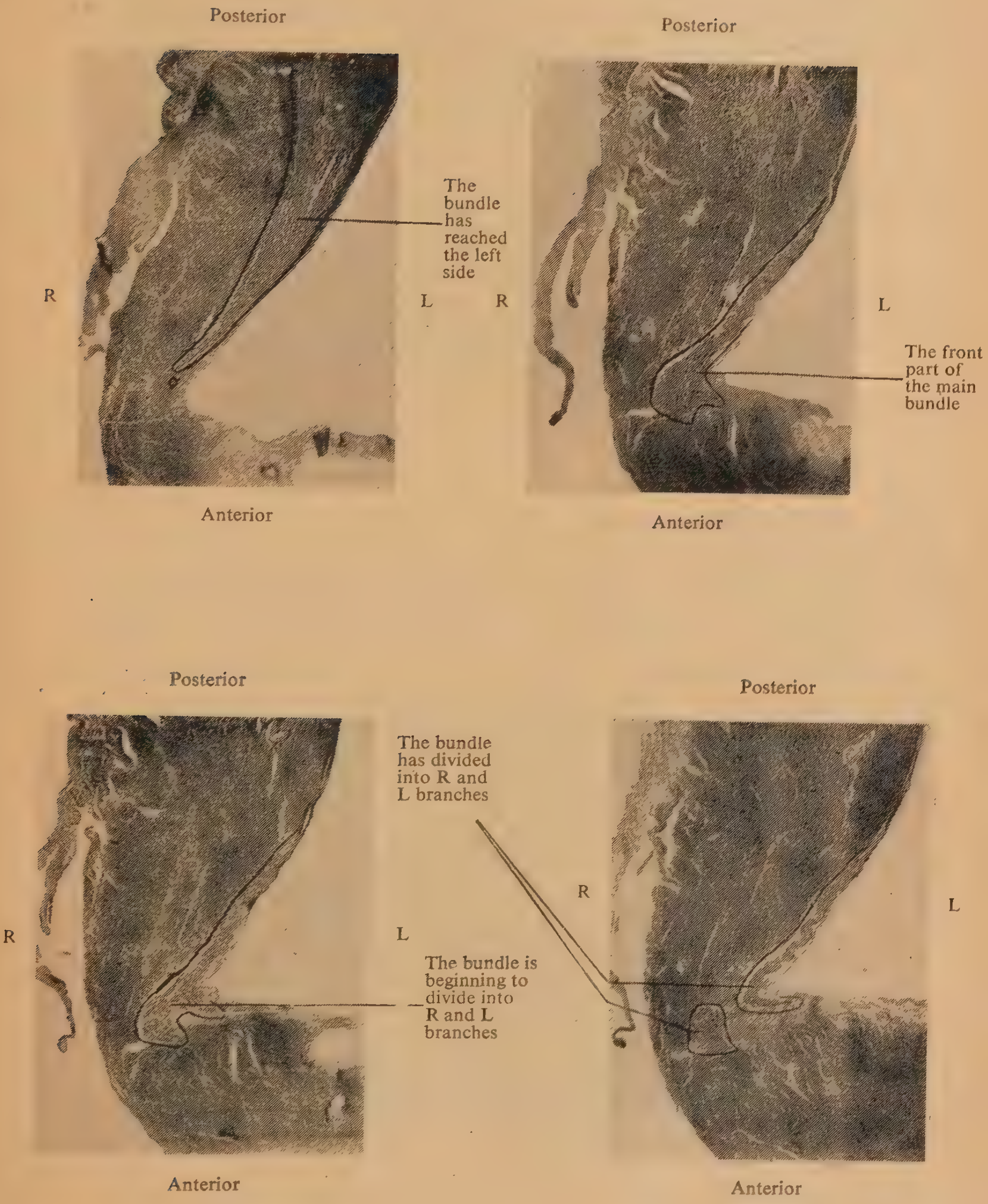

Posterior
The bundle has reached the left side
R
L
Anterior
Posterior
R
L
The front part of the main bundle
Anterior
Posterior
R
L
The bundle is beginning to divide into R and L branches
Anterior
Posterior
The bundle has divided into R and L branches
R
L
Anterior

FIG. 5.—Bundle of His and two main branches. (× 18 diam.)

normal ventricular sequence. This is followed by a compensatory pause, and the next auricular beat follows in its normal time (the normal auricular rate) and the normal rhythm is re-established. The time occupied by a normal beat together with the extrasystole and its compensatory pause is shorter than the time occupied by two normal beats.

(3)—Ventricular Extrasystole

In Fig. 9 the 2nd, 5th and 8th ventricular complexes are larger, broader and higher than the normal supraventricular complexes. Rs ^{2}, ^{5}, ^{8} are continued into broad T-waves in an opposite and downward direction, the auricular rhythm being unaffected; a premature beat may follow a normal beat early or late provided the ventricular muscle is not refractory. The time occupied by the normal beat together with the extrasystole and its compensatory pause is usually equal to the time occupied by two normal beats. Fig. 10 shows a form of bigeminal pulse where every normal auriculo-ventricular sequence is followed by an extrasystole.

(4)—Clinical Recognition

Examination of patient

Extrasystoles can be readily detected by the simultaneous use of stethoscope over the heart and fingers on the radial artery. With the finger on the radial artery occasional and irregular pauses may be felt or beats may appear in couples, the first of the couple being the larger beat (pulsus bigeminus); or it may be that every third or fourth beat is an extrasystole. By simultaneously listening to the heart and feeling the radial pulse, the premature beat will be heard at the apex and the pulse will record a small premature beat or a complete 'miss'. The extrasystole may be so premature that the semilunar valves are not opened, and in that case there will be no corresponding impulse in the radial artery. The later the extrasystole occurs the more likely are the semilunar valves to be opened and a 'pulse' felt in the radial artery. If there is any difficulty in hearing the premature sounds (extrasystoles) with the patient standing, sitting, or lying on the back, they can invariably be heard when the patient is rolled on to the left side. Whether a small impulse is felt in the radial artery, or whether there is a complete absence of pulse, the detection of a premature beat can always be made by the stethoscope. Quickening of the heart tends to do away with the appearance of extrasystoles, and in cases of doubt exercise or an inhalation of amyl nitrite will make them disappear temporarily. At times extrasystoles can be made to appear as the heart begins to slow following temporary quickening after exertion.

(5)—Symptoms

The sensations of which the patient, the subject of extrasystoles, complains are usually the following. He is either conscious of the abnormal beat, i.e. the extrasystole itself, or he feels that his heart has stopped during the intermission, or he is bothered by the big impulse of the

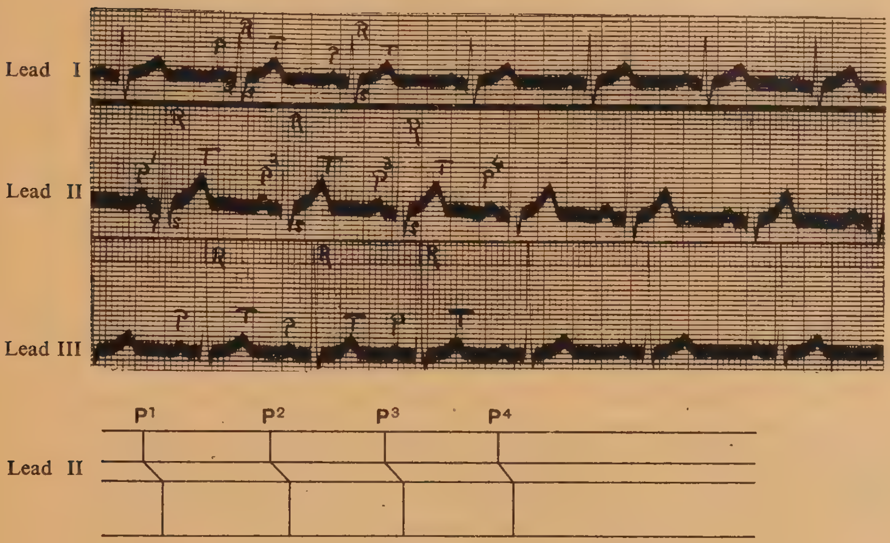


FIG. 6.—Normal electrocardiogram

P = auricular contraction. QRS = beginning of ventricular contraction. T = end of ventricular contraction.

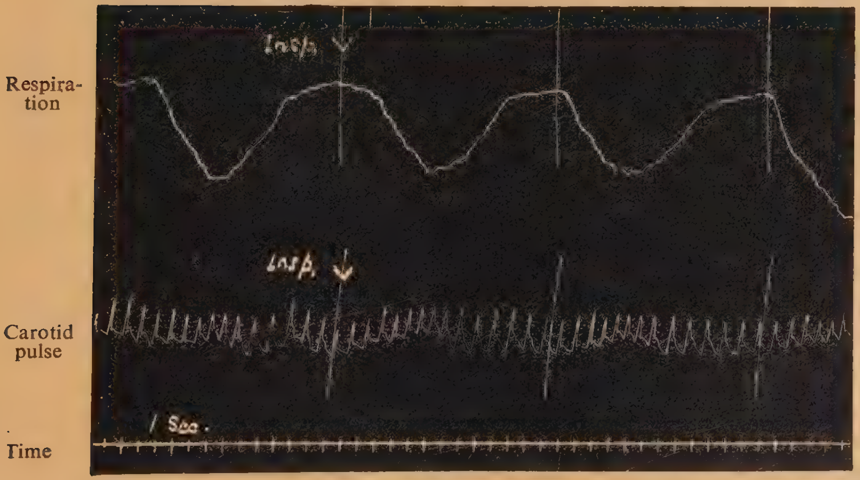


FIG. 7.—Tracings showing sinus arrhythmia. Heart-rate quickens in inspiration. 'Insp.' = beginning of inspiration (downward)

normal beat following the extrasystole. The extrasystole itself gives rise to a sensation of the heart 'turning over' or 'the heart rises into the throat'. There may be a vague chest sensation and a feeling that the heart has missed a beat altogether, or consciousness of a pause followed by a big thump in the chest. When extrasystoles are of infrequent occurrence, any discomfort is probably ignored and soon forgotten; but if of frequent occurrence the patient may become alarmed fearing that he has heart disease. In nervous individuals, the sensations may be frightening and may cause a feeling of faintness. Extrasystoles are most noticeable on first going to bed at night, the patient mentioning that he is unable to lie on his left side. Indeed, extrasystoles are always most troublesome at rest because they are more prone to occur when the heart-rate is slow.

(6)—Aetiology

Extrasystoles are more frequent in the middle-aged and the old than in youth.

Although extrasystoles occur in association with organic heart disease of every variety, they have no serious significance in themselves. They probably occur in most people at some time in their lives, and their actual causation is very varied. The cause is usually discoverable in some physiological or pathological derangement of organs other than the heart itself. They may appear in all forms of infection and are evidence of some direct effect of the poison upon the heart. In pneumonia, the rapid and regular rate of the heart is sometimes broken by the occurrence of extrasystoles. In more chronic conditions they are extremely frequent, particularly in all forms of indigestion and perhaps this is the commonest cause. Certain definite poisons, such as tobacco and digitalis, are a frequent source of extrasystoles; over-exertion and fatigue account for them in some instances. They cause their greatest distress in nervous and dyspeptic individuals. At times no particular cause can be discovered, the important fact being that the cause has usually to be discovered outside the heart. They occur as peculiarities in certain families and in the writer's experience through four generations.

(7)—Differential Diagnosis

From heart-block

The commonest error lies in mistaking an extrasystole for a missed beat in heart-block, but careful attention with the stethoscope to the sounds at the apex with a finger on the radial pulse should always be sufficient to differentiate between them. If extrasystoles are occurring they can always be heard—particularly if the patient is rolled over on the left side. In a condition of incomplete heart-block there is complete silence at the apex during the missed beat.

From auricular fibrillation

It is only rarely that confusion arises between frequent extrasystoles and auricular fibrillation. It does happen that extrasystoles may be generated from auricles and ventricles and from different levels in the ventricles, and this gives rise to a very irregular pulse, and the similarity to auricular fibrillation is very great. It must

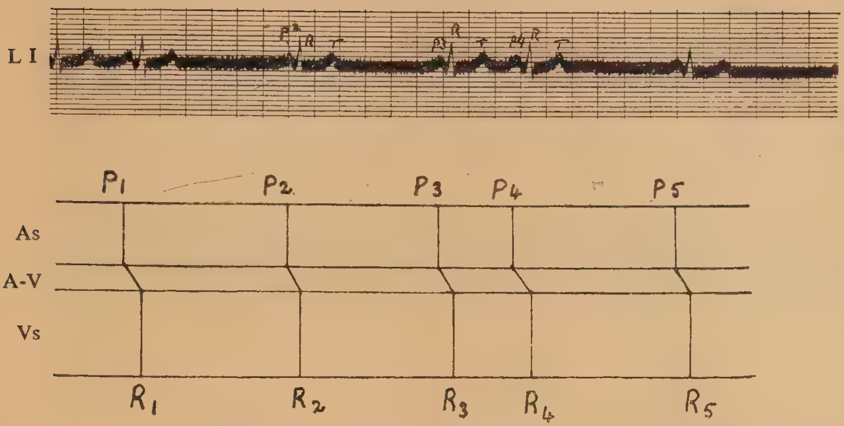


FIG. 8.—Electrocardiogram showing auricular extrasystole. The fourth auricular beat is premature. R_3 to $R_5 < R_1$ to R_3

always be remembered that speeding-up the heart cuts out the extrasystoles, so that in a case of doubt, increasing the speed of the heart will produce a normal rhythm which had previously been interrupted by extrasystoles. In a bedridden patient unable to take exercise extrasystoles occurring from various levels in the heart could only be clearly distinguished from auricular fibrillation by means of an electrocardiogram.

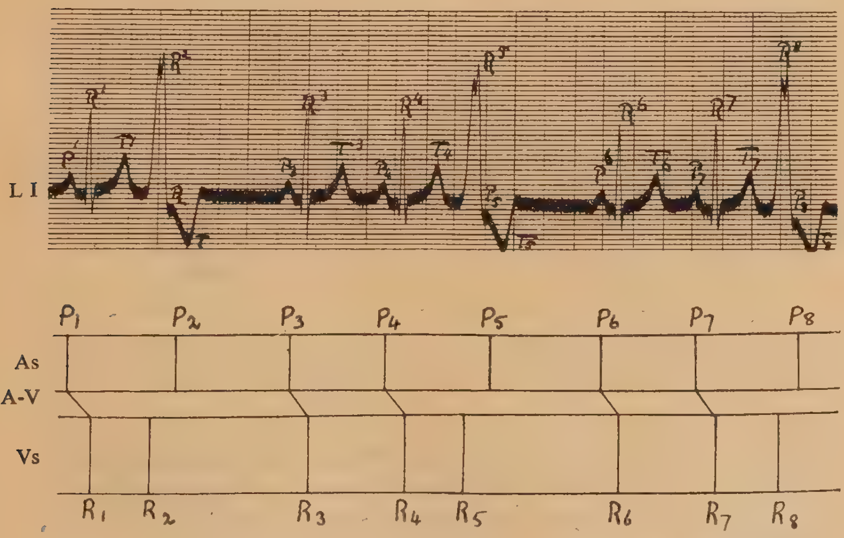


FIG. 9.—Electrocardiogram showing ventricular extrasystole. The diagram demonstrates the mechanism—the auricular rhythm is undisturbed

(8)—Treatment

Having recognized the fact that the arrhythmia is due to extrasystoles, the sufferer's mind should first be set at ease by explaining to him that this type of irregularity is of no serious consequence. If it is obvious that there is some definite cause, such as tobacco or some form of dyspepsia, the removal of the one or the alleviation of the other will do away with the irregularity. When the cause is not obvious a mixture of bromides and alkalis is probably the most suitable form of medicine. In those who are infrequently bothered with extrasystoles, the following mixture is useful with instructions to the patient only to take a dose when he feels that they are occurring:

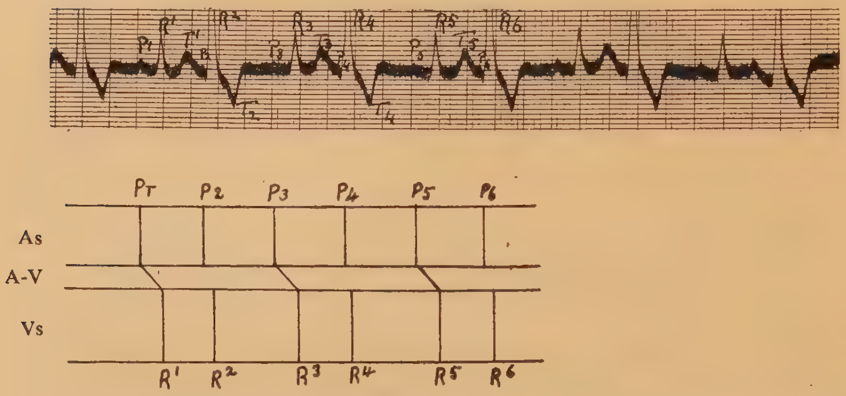


FIG. 10.—Electrocardiogram showing ventricular extrasystole. Alternating premature ventricular beats—bigeminal pulse. Auricular rhythm undisturbed

Aromatic spirit of ammonia – –	15 minims
Spirit of ether – – – –	10 minims
Compound tincture of cardamom –	30 minims
Peppermint water to – – –	½ fl. ounce

Dose: ½ fl. ounce in water when required.

Quinidine sulphate 6 grains twice or thrice daily frequently abolishes extrasystoles in those persons in whom they occur frequently, causing discomfort for no obvious cause. But whatever therapeutic measure is prescribed the patient should be persuaded that the arrhythmia is of no serious importance.

4.–TACHYCARDIA

(1)—Simple Tachycardia

(*Synonym.*—Sino-auricular tachycardia)

Definition 81.] Regular and rapid action of the heart with gradual onset and offset.

Aetiology The causes of rapid heart action are numerous and varied.

(1) In some healthy individuals the heart-rate may be always rapid (90) even at rest.

(2) Quickening of the heart is a normal response to exertion, pain, excitement, fatigue, loss of blood, haemorrhage and shock.

(3) Nearly all febrile states are associated with an increase of rate, and the ratio is commonly an increase of 10 beats per minute for every rise of 1° F. of temperature. In some fevers such as the enteric group the ratio is only 5 : 1.

(4) Drugs of the atropine and nitroglycerin groups are associated with tachycardia; atropine by paralysing the nerve-endings of the vagus and nitroglycerin by lowering blood-pressure. A rise of blood-pressure tends to slow the heart-rate and sudden lowering tends to quicken it.

(5) Tea, coffee and tobacco and indigestion are frequent causes.

(6) Local infections of teeth and tonsils and focal infection in the lungs, even without fever, may cause a persistent tachycardia.

(7) An abnormally quick heart-rate may persist in convalescence after various illnesses and is frequently the only clear evidence that the heart is still poisoned by rheumatic fever, after the acute manifestations have disappeared.

(8) Thyrotoxicosis.

(9) Neuro-circulatory asthenia, the effort syndrome, D.A.H., are terms employed to denote a nervous instability of the circulatory system in which the heart-rate is either temporarily or persistently rapid.

(10) In heart failure, particularly the later stages of hypertension, the speed is increased, suggesting that the heart is endeavouring to achieve by speed that which it fails to accomplish by force.

Symptoms

In the various nervous forms of simple tachycardia the heart beats forcibly and the patient is conscious of, and may be distressed by, the thumping against the chest wall. Breathlessness, aching in the region of the apex and anxiety often accompany the palpitation.

Signs

The heart by its 'thumping' may suggest hypertrophy or dilatation; systolic exocardial murmurs are common over the precordium and have no pathological significance.

Differential diagnosis

When patients complain of attacks of palpitation and rapid heart action, a few questions will usually make it obvious that the attack is one of simple tachycardia and not a paroxysmal tachycardia. In the latter the onset and offset are abrupt, the attack commences and ends in one beat, whereas in simple tachycardia the end comes gradually by a steady diminution of heart-rate.

Treatment

Treatment consists in the discovery and removal of the cause and in reassurance that the heart is essentially normal in those instances where there is no evidence of organic disease.

(2)—Paroxysmal Tachycardia

(*a*) *Definition and Mechanism*

Paroxysmal tachycardia is an attack of very rapid heart-action which begins and ends suddenly. The heart takes on a new rhythm, and during the attack beats at a rapid and very constant rate of about 200 a minute; usually it lies between 180 and 220. The attack may last minutes or hours, and ends with the same abruptness with which it started; in one beat the rhythm changes from normal to abnormal, and at the end of the attack it changes back in one beat.

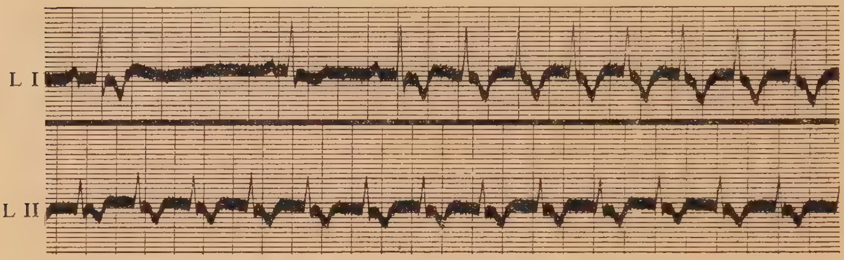


FIG. 11.—Electrocardiogram showing onset of attack of paroxysmal tachycardia. In the third beat of lead I the attack starts and is continued throughout lead II

Site of pacemaker

In paroxysmal tachycardia the pacemaker of the heart has changed its site from the sino-auricular node to some other focus. This focus may be in the auricles, in the ventricles, or in the junctional tissues between them, so that three varieties of paroxysmal tachycardia are described: (*a*) auricular, (*b*) ventricular, and (*c*) nodal. In any given case, the actual level of the new pacemaker can only be determined by means of an electrocardiogram. Fig. 11 shows the onset of an attack at the third beat of lead I, the attack continuing throughout lead II. Fig. 12 shows a paroxysm of tachycardia in another case at the rate of 180 per minute.

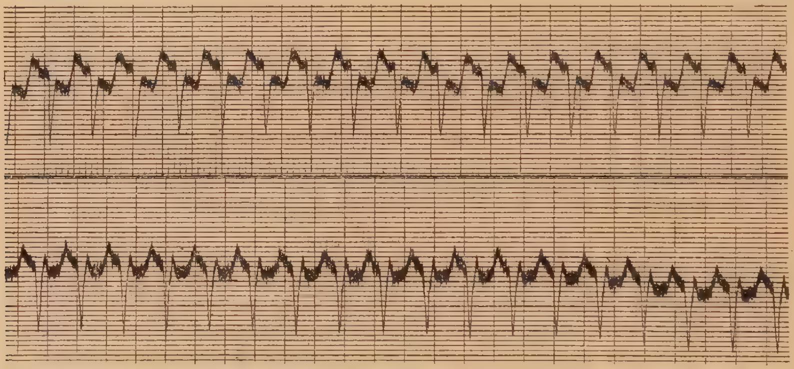


FIG. 12.—Electrocardiogram showing paroxysmal tachycardia. Ventricular rate is approximately 180 per minute

and Fig. 13 shows the cessation of an attack as the result of pressure on the left carotid sinus. Both Figs. 11 and 13 demonstrate the characteristic abruptness of both the onset and offset of attacks of paroxysmal tachycardia.

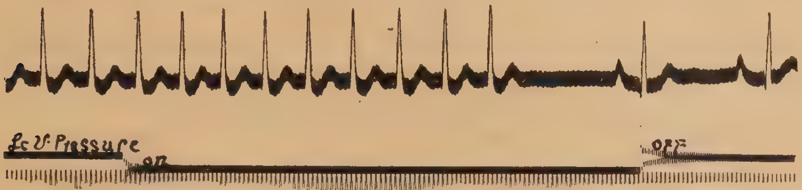


Fig. 13.—Electrocardiogram showing the termination of an attack of paroxysmal tachycardia by pressure on the left carotid sinus. The attack ends abruptly. (Reproduced by courtesy of Prof. W. T. Ritchie)

Recognition of the site of the new pacemaker is not of paramount importance. Roughly 78 per cent arise above the ventricles and 20 per cent arise in the ventricles, those of supra-ventricular origin being for the most part of less serious significance than ventricular tachycardia (Fig. 14).

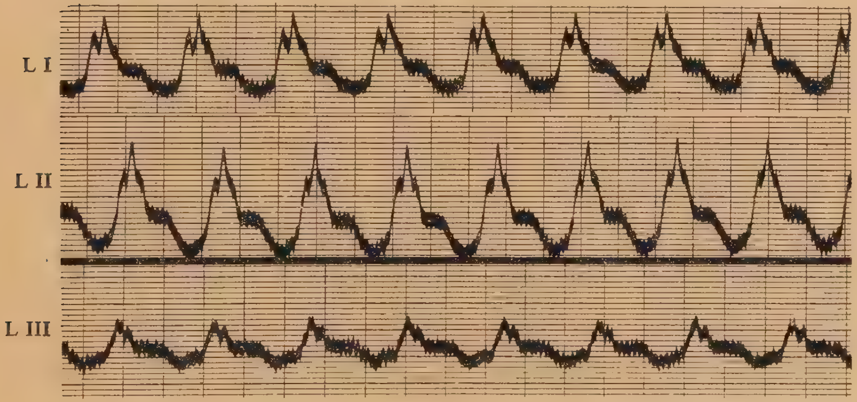


Fig. 14.—Electrocardiogram showing ventricular tachycardia, from patient dying of myocardial disease. Ventricular rate = 125 per minute. Evidence of auricular activity is uncertain

(b) Symptoms

Onset The attack usually starts without any warning, though there are certain movements which seem to determine an attack in those who are prone to them. Bending movements particularly may bring on an attack, and nearly all sufferers mention that they have long since ceased to bend to fasten their shoes. In some an attack is determined by emotion; in others by violent exertion. The majority, however, start from no ascertainable cause. Most individuals are in discomfort during the attack, and prefer to sit rather than to lie down. Occasionally, they are able to continue their occupation of the moment, but sometimes fear makes the discomforts very formidable.

Description of attack

Most attacks are of short duration, the circulatory system is not seriously impeded except from the point of view of speed, and sufferers are neither breathless nor in pain. Giddiness is frequent, though fits and unconsciousness ensuing from the consequent cerebral anaemia are rare occurrences. If the attack is prolonged so as to last for days, the apex of the heart will move downwards and outwards, and the liver may swell, with other evidences of congestive failure. In the vast majority of cases the attack lasts less than 12 hours and the duration may be very constant in the particular individual. Most sufferers from paroxysmal tachycardia are very conscious of the moment when the attack ceases and feel immediate relief. The frequency with which attacks occur varies considerably; in the majority they occur at comparatively long intervals—a month or six weeks. I have known individuals pestered throughout their lives from the age of eighteen to seventy by an average of four to five attacks a year. Examination of the heart by X-rays during an attack shows that the dimensions of the heart are less than normal, and it is only after an attack has lasted for some time that dilatation is likely to occur. As attacks of paroxysmal tachycardia occur more often in those with normal hearts than in those with diseased hearts, it is important that the cardiovascular system should be examined between attacks. Organic heart disease *is* associated with attacks of paroxysmal tachycardia. Auricular tachycardia is not uncommon in association with mitral stenosis, and most instances of ventricular tachycardia occur in those who have grossly diseased hearts, and occurs therefore towards the end of life.

Prognosis

The prognosis in any particular case is usually good and depends on the condition of the heart apart from the attacks, since no evidence of cardiovascular disease is found in the majority of cases.

(*c*) *Treatment*

Treatment of attack

The treatment consists in that of the attack itself and in an attempt to prevent future attacks. Many sufferers have discovered some method of stopping their attacks such as holding the breath, pressure on the abdomen, or sudden change of posture; induced vomiting is effective in individual cases. If the patient has been unable to arrest the attack himself, the medical attendant may be able to stop the attack by pressure on the carotid sinus or on the eyeball. Theoretically, pressure on the right carotid sinus should be more effective than the left, as the heart receives the larger nerve supply from the right vagus. Sitting on the bed facing the patient with the left thumb over the bifurcation of the right carotid artery and the fingers behind the neck, steady pressure sufficient to obliterate the carotid pulse is applied for about a minute, while the stethoscope is kept over the heart to test the effectiveness of the procedure. If the right side fails, the left may be similarly pressed with the right thumb. If both have failed, steady pressure on one or other eyeball while the patient looks downwards may bring about an arrest.

Attacks of auricular origin are more readily brought to an end than those of nodal or ventricular types. If pressure fails to bring an attack to an end, and the patient is becoming exhausted or is very nervous, a small dose of morphine sufficient to bring about sleep will usually be effective. During sleep the attack will cease spontaneously and the patient awake refreshed. The patient should be reassured that even if all remedies fail the attack is certain to cease spontaneously. Intravenous injection of quinidine sulphate is reputed to bring about a cessation when every other remedy has failed, but this form of therapy is not without danger and in the light of experience is not justified. As an alternative, quinidine sulphate, 6 grains, may be given every two hours by mouth. Prevention of future attacks is very difficult, but the patient learns to avoid those movements and exertions which he has found to induce attacks in the past. Indiscretion in diet, especially overloading, is a frequent immediate cause, and a daily dose of quinidine sulphate, 6 grains, has minimized the number of attacks in some cases.

Prevention

5.—BRADYCARDIA

(1)—Mechanism

82.] The normal heart-rate generated at the normal pacemaker, the sino-auricular node, is usually about seventy beats a minute, but the stimulus formation may be at a much slower rate, some individuals having a natural heart-rate of fifty, forty, or even fewer beats per minute. Vagal stimulation tends to slow the speed, and slow heart-rates are common in convalescence following many infections.

(2)—Sino-Auricular Block

In this type presumably the stimulus generated in the sino-auricular node fails to excite the auricles to contract. The result is the omission of one cardiac cycle.

In another variety the auricular rate is so slow that the ventricles contract before receiving a stimulus from the auricles. A stimulus to ventricular contraction has arisen in the lower auriculo-ventricular node—a so-called ventricular escape. These varieties, which are infrequent and of no particular significance, can only be recognized with certainty by electrocardiography. Atropine will occasionally remove the disability in those rare instances in which irritation in the neck by infections and tumours has caused stimulation of the vagus.

(3)—Auriculo-Ventricular Block (Heart-Block)

This is caused by various pathological conditions. The existence of the heart-block presumes a defect in conductivity in the auriculo-ventricular node or main bundle, due probably to some functional defect or to actual pathological changes in the node and bundle; it is occasionally congenital.

(*a*) *Temporary*

Causes

Depression in the conductivity of the auriculo-ventricular node and bundle may be brought about by infections. Instances have been encountered in pneumonia, tonsillitis, acute rheumatism, diphtheria, and many other infections. Frequently in instances of this sort, in addition to there being a temporary block between auricles and ventricles, there is a general slowing of conductivity between auricles and ventricles so that the auriculo-ventricular interval (P—R interval) is unusually prolonged. This is seen in Fig. 15; the P—R interval is greatly lengthened until at the second and seventh beats the auricular impulse is not followed by a ventricular impulse. Clinically, temporary incomplete heart-block is recognized by occasional intermissions at the radial pulse. When the region of the apex of the heart is examined with a stethoscope during these intermissions, there is a complete silence. Instead of occasional auricular impulses failing to reach the ventricles, every alternate auricular impulse may fail, and in this way very slow ventricular rates will result.

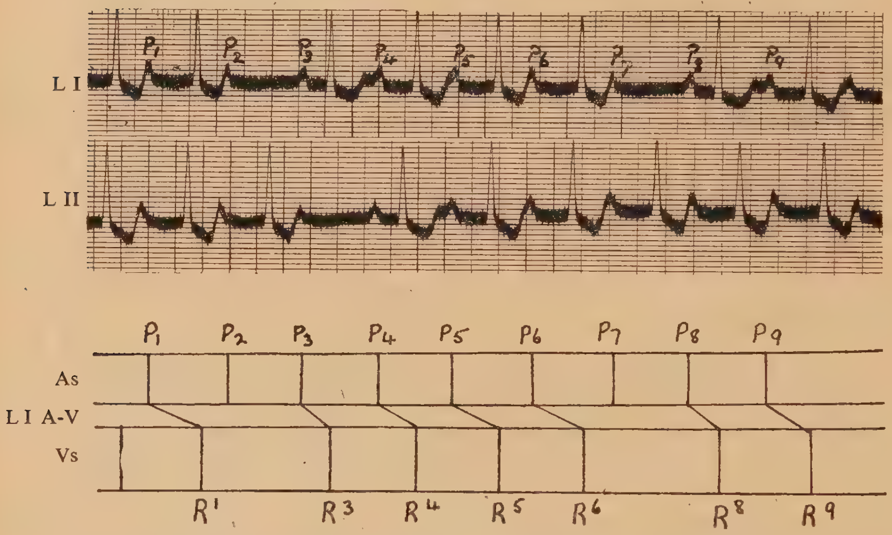


FIG. 15.—Electrocardiogram showing auriculo-ventricular block, varying conductivity of A-V bundle, gradually lengthening from P_3 up to P_7 where a ventricular response is missing

(*b*) *Complete*

auses

This condition usually occurs when much fibrous tissue has been deposited in the heart-muscle. It may follow a thrombosis of a coronary artery when the infarcted area of heart-muscle has been replaced by fibrous tissue, or it may occur in hearts in which the muscle has become more universally transformed into fibrous tissue. Rarely, a local inflammation such as a gumma may be deposited in the track of the auriculo-ventricular bundle. If the ventricles have been completely cut off from the auricles, the former generate their own rhythm, probably from the auriculo-ventricular node. The spontaneous ventricular rate in the human heart is about 30 to 35; in fact, a regular ventricular rate of 30 to 35 in an adult usually means auriculo-ventricular heart-block. If further proof, besides the slow regular rate of about 30, is needed, a study of the veins in the neck may show regular definite impulses occurring during ventricular diastole due to auricular impulses which have failed to reach the ventricles. Auricular impulses can be demonstrated by polygram or electrocardiogram. When the ventricles are completely cut off from the auricles the rate may fall considerably below 30, and slow rates such as 15 to 25 cause an impoverished supply of blood to the brain, so that giddiness and faintness are common. Slow rates are apt to be associated with fainting and convulsions (Adams-Stokes syndrome). A difference of 4 or 5 beats a minute commonly determines the comfort of the patient; at a ventricular rate of 32, a man may be able to move about quietly, whilst at a rate of 26 to 28 he may be unable to leave his chair without discomfort. Fig. 16 shows complete auriculo-ventricular dissociation.

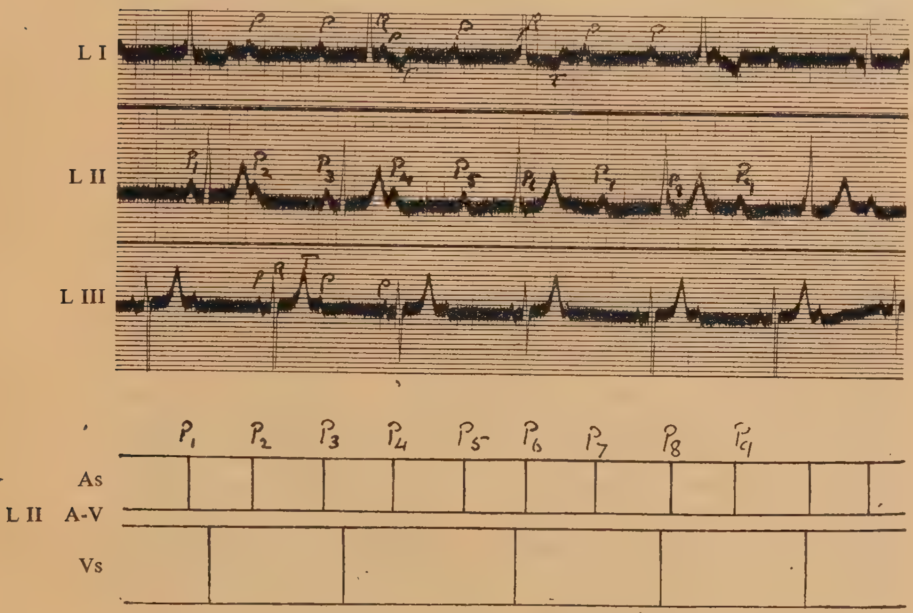


FIG. 16.—Electrocardiogram showing auriculo-ventricular block. Diagram explains the auriculo-ventricular relationships in lead II

(4)—Treatment

An idio-ventricular rhythm is extraordinarily independent of nervous and other influences. A patient with heart-block may pass through an attack of pneumonia and the ventricular rate never exceed 35 to 40.

Exertion seldom increases the ventricular rate. Very rarely, the independent ventricles will assume a speed of 60, where there is proof that the auricles and ventricles are completely dissociated. Although such a quickening occasionally occurs spontaneously, it is extremely difficult to bring it about artificially. If a patient is found to have a slow pulse below 20 and is subject to fainting attacks or even to convulsions, adrenaline hydrochloride solution (1 in 1,000), 5 to 10 minims subcutaneously, may temporarily quicken the independent ventricles and relieve the cerebral anaemia. It is sometimes necessary to anaesthetize patients having continual epileptic convulsions. In those who are going about with slow rates of about 25, an increase of a few beats a minute may be maintained by frequent hypodermic injections of adrenaline chloride or ephedrine.

6.–BRANCH-BUNDLE BLOCK

83.] When the auriculo-ventricular bundle is obstructed a condition of partial or complete heart-block results. Similarly one or other of the main branches may be involved in pathological processes in the heart-muscle, and the condition is known as branch-bundle block. This condition can only be recognized by the characteristic electrocardiogram.

Description Branch-bundle block usually implies widespread fibrous tissue changes in the heart-muscle generally. The terminations of the two branches may be involved, and this condition is known as arborization block. Characteristic electrocardiograms are obtained when one or other of the main bundles are involved. Fig. 17 represents the commoner type. The rhythm is regular, but although there is evidence of regular auricular contraction in all three leads the ventricular complexes are abnormal. In lead I there are broad notched Rs continued into a well-defined T in a downward direction, while in lead III there is a broad notched S continued into a broad T in an upward direction.

In the second less common type (Fig. 18) the appearance of Rs and Ss in leads I and III are the reverse of those seen in Type I. There is the same auricular control, but S in lead I is broad and prominent, and in lead III R is broad and notched.

There is some doubt as to the actual side involved in these distinctive electrocardiograms which are accepted as evidence of branch-bundle block, and at present they are best designated as Type I and Type II. They are both important because they denote pathological processes in the heart muscle, and are found associated with hypertrophied hearts in hypertension either with or without kidney disease. They are also found to follow thrombosis of the coronary arteries. The appearance of branch-bundle block lesions has a serious prognostic significance, since most patients die within two years of their discovery.

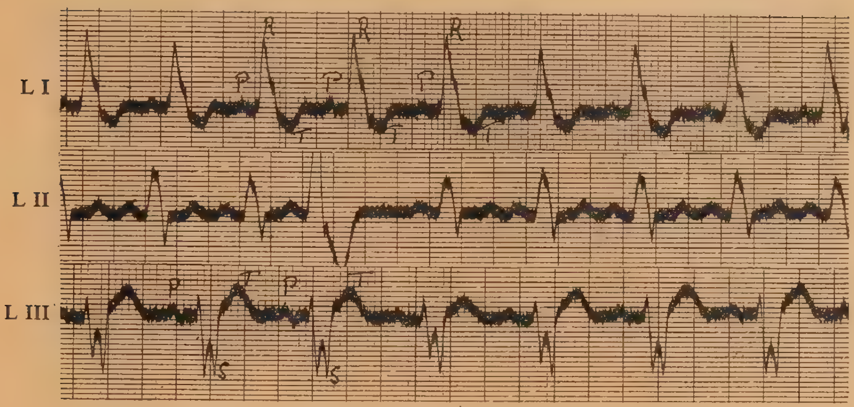


FIG. 17.—Electrocardiogram showing branch-bundle block Type I. In lead I there is a broad R followed by downward T; in lead II there is a broad S followed by an upward T

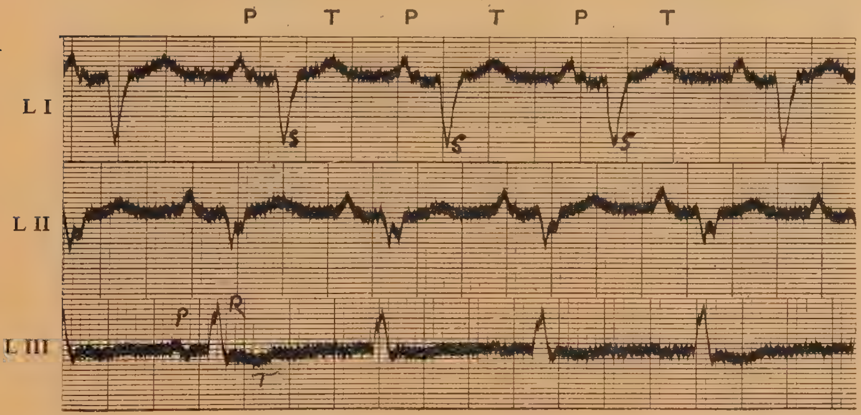


FIG. 18.—Electrocardiogram showing branch-bundle block Type II. In lead I there is a broad S followed by upward T; in lead III there is a broad R followed by downward T

7.–AURICULAR FLUTTER AND AURICULAR FIBRILLATION

Definition of flutter

84.] These abnormalities of auricular activities are closely allied. In 1880 MacWilliam demonstrated both conditions by faradization of the auricles of cats' hearts. If the auricles of a cat's heart are stimulated by a faradic current they will be seen to contract very rapidly at a speed of 300 to 400 times per minute, and to become pink on contraction. This rapid regular contraction is known as auricular flutter.

Definition of fibrillation

Such regular auricular contraction is frequently replaced by a different variety of auricular activity. The walls of the auricles now appear to be in perpetual vermicular movement. Uniform contraction of auricular musculature is absent, and the auricles appear as blue distended sacs whose walls are alive with fibrillary movement. The ventricles are seen to be contracting rapidly and very irregularly. This condition is known as auricular fibrillation. By using the electrocardiograph on patients, Lewis and others proved that both these conditions occurred in man.

(1)—Auricular Flutter

Mechanism

The auricular rate in auricular flutter in man varies between 260 and 320. The ventricles frequently respond to alternate auricular impulses and beat at half the auricular rate, a 2 : 1 response. In some cases the ventricular response is less frequent and the ratio may then be 3 : 1, 4 : 1, and higher. When at times the response is variable, 2 : 1, 4 : 1, or 8 : 1, the pulse appears very irregular and suggests auricular fibrillation. Auricular flutter may occur in paroxysms or as a permanent arrhythmia. Paroxysmal attacks are more common than the established condition. Fig. 19 shows auricular flutter at an auricular rate of 300.

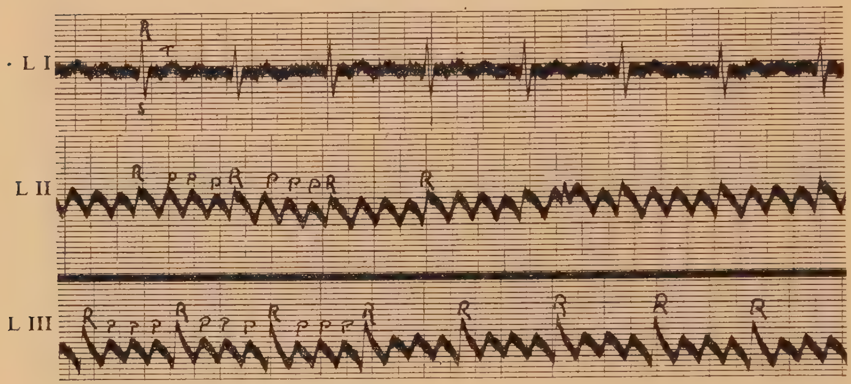


FIG. 19.—Electrocardiogram showing auricular flutter. The P waves are obvious in leads II and III, and the auriculo-ventricular response is 4 : 1. Auricular rate = 300

Aetiology

It is much commoner after the age of forty than before middle life, and is very similar to auricular fibrillation in its associated cardiac conditions. It is met with in rheumatic heart disease, thyrotoxicosis, myocardial disease, and at times affects otherwise normal hearts. It is much less common than auricular fibrillation, the ratio being not more than 1 to 20.

Signs and Symptoms

Usually the patient complains only of palpitation. The ventricular rate may be very rapid and regular if the auriculo-ventricular ratio is 2 : 1, or irregular if the ratio varies 2 : 1, 3 : 1, or 4 : 1. A persistent rapid ventricular rate of about 150 would always suggest the presence of auricular flutter. It usually lasts hours, days or weeks—seldom persisting unchanged into months or years—although it has been known to persist for five to seven years.

Treatment

Pressure on the carotid sinus will usually temporarily reduce the ventricular rate, although it will not terminate the attack as it frequently does in paroxysmal auricular tachycardia. Digitalis is to be administered in full doses as is described in the treatment of recently established auricular fibrillation. Under digitalis treatment auricular flutter occasionally passes into auricular fibrillation, and when this occurs quinidine sulphate may be given in an attempt to restore a normal rhythm.

(2)—Auricular Fibrillation

Mechanism

This is a common form of cardiac irregularity and it is of prime importance. Transient paroxysmal attacks may occur which herald the onset of permanent auricular fibrillation in those pathological conditions of the heart which are specially prone to it. On the other hand paroxysmal attacks of auricular fibrillation may harass a patient intermittently for years, without the condition ever becoming permanently established. Such temporary attacks are occasionally encountered in acute diseases, such as pneumonia and throat infections, as well as in subjects who otherwise show no abnormality in the cardiovascular system or elsewhere. Temporary paroxysmal attacks are more common in rheumatic heart disease and thyrotoxicosis, but in these diseases auricular fibrillation is more likely to become a permanent state.

Fig. 20 is an electrocardiogram showing hypertension with myocardial failure. The irregularity of the ventricles is apparent in all three leads; the interval between Rs is completely variable; and in lead III the diastolic periods are seen to be broken by small coarse irregular waves indicative of the fibrillary movement in the auricles. There is no P wave.

Fig. 21 is a simultaneous electrocardiogram and sphygmogram. The beats in the pulse vary both in strength and regularity and are larger after the longer diastolic pauses. When the auricles are fibrillating impulses pass over to the ventricles by way of the auriculo-ventricular node, main bundle, and branches to the ventricles in a rapid and completely haphazard manner, the ventricles responding as best they can. The rate of response depends to a large extent on the condition of the connecting system. At the onset of auricular fibrillation the ventricular response is usually at a considerable speed, about 140 per minute. Diminished conductivity in the bundle of His will tend to slow the ventricular rate, and in this way digitalis, by giving them greater rest, produces a greater efficiency of the ventricles.

Clinical Recognition

Auricular fibrillation can usually be detected by examination of the radial pulse, which is completely irregular both in time and force. The same variability is found on examination of the heart with the stethoscope, and it will also be observed that many of the first sounds of the heart have no corresponding representatives in the radial pulse. Sounds are heard at the apex and there is either a faint kick in the pulse or nothing to be felt at all. In the space of a minute a greater number of sounds can be heard at the apex than beats can be counted at the radial pulse. This is the so-called pulse deficit.

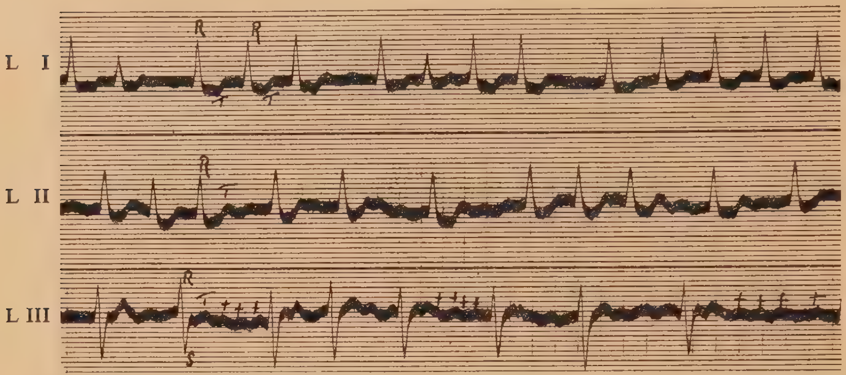


FIG. 20.—Electrocardiogram showing auricular fibrillation. Intervals between Rs are completely irregular. There is no P wave. + + indicate movements due to the fibrillating auricles

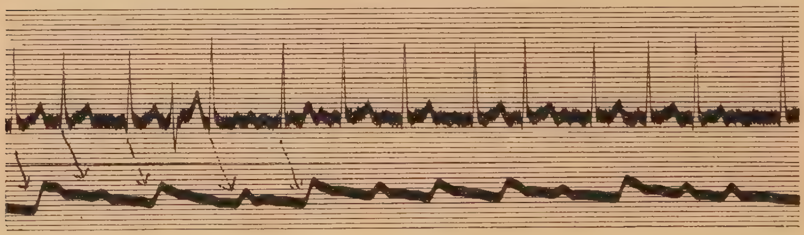


FIG. 21.—Auricular fibrillation. Upper tracing, an electrocardiogram. Lower tracing, radial pulse. Arrows indicate the relationships between heart-beats and corresponding pulses

In auricular fibrillation the heart is still under the control of vagal and sympathetic influences, and exertion and emotion will increase the rapidity of the ventricles. Increasing the speed of the ventricles makes the irregularity of the heart more obvious, and auricular fibrillation can be distinguished from extrasystoles in this way, as the latter tend to disappear when the heart-rate is quickened.

Mechanism of fibrillation

The exact mechanism by which auricular fibrillation is produced is not completely understood. Lewis has suggested that it is of the nature of a circus movement. A wave of contraction is continually circulating round a ring of auricular musculature and exciting neighbouring bundles of fibres to contract. This thesis implies a diminution of the refractory period of the auricular muscle. The muscle is too easily and too early excitable. Anything therefore which would increase and lengthen the refractory period would tend to abolish the fibrillation, and it is probable that the efficacy of quinidine is thus explained. Auricular fibrillation implies either a functional and temporary derangement as in paroxysmal fibrillation, or more frequently occurs in association with damaged hearts. In the latter type the moment of onset may be determined by muscular strain or infection. Clinically the conditions with which auricular fibrillation is most frequently associated are the following: (*a*) rheumatic heart disease, especially mitral stenosis, (*b*) the thyrotoxic heart, and (*c*) myocardial disease with or without hypertension.

Rheumatic Heart Disease

When auricular fibrillation occurs in association with rheumatic heart disease it can almost always be presumed that mitral stenosis is present. It is very rare to find auricular fibrillation in a case of aortic regurgitation due to rheumatic valvular disease, without the presence of mitral stenosis. The onset of auricular fibrillation marks a stage of decompensation in a case of mitral stenosis. It is well recognized that the typical presystolic crescendo murmur heard with a regular rhythm disappears with the onset of auricular fibrillation, though there may be, and usually is, a diastolic murmur whose greatest intensity is at the beginning of diastole. The age at which auricular fibrillation occurs in rheumatic heart disease is usually between twenty-five and thirty-five.

Thyrotoxic Heart

Auricular fibrillation occurs in both uniform and irregular enlargements of the thyroid gland, and occasionally when the gland is not obviously enlarged. Auricular fibrillation may appear at any time—even late in life—in persons who all their lives have been the subject of an adenomatous goitre. When auricular fibrillation has occurred there is usually some evidence of enlargement of the heart; and, occasionally, systolic and diastolic murmurs appear, and thrills will be felt very similar to those found in mitral stenosis.

Myocardial Type, with or without Hypertension

In patients over the age of forty-five in whom there is no evidence of rheumatic heart disease or of thyrotoxicosis, but in whom auricular fibrillation is discovered, it is presumed that some myocardial degeneration has taken place. In many instances, the heart has suffered as part of a general cardiovascular degeneration, such as arteriosclerosis and hypertension. The assessment of blood-pressure is always somewhat difficult when auricular fibrillation is present, but in spite of the irregularity and inconstancy of rhythm and force, some idea can be obtained of both the systolic and diastolic blood-pressures by the auscultatory method.

In some persons it may have been known that previous to the onset of auricular fibrillation the blood-pressure was abnormally high.

The systolic blood-pressure invariably falls at the onset of auricular fibrillation, and although hypertension probably accounts for the majority of cases falling under this group, there are instances of auricular fibrillation occurring in older people in whom there is no evidence of high blood-pressure or enlargement of the heart. The only abnormality to be discovered is the fact that auricular fibrillation is present.

Treatment

The treatment of auricular fibrillation embraces both treatment of the abnormal rhythm and also that of the underlying condition of the heart-muscle which has produced the condition and, therefore, varies in the three groups.

Mitral stenosis type

When auricular fibrillation replaces the normal rhythm in a case of mitral stenosis, it usually imposes a very rapid rate upon the ventricles. This in turn may produce considerable degrees of decompensation and congestive failure. In cases of this sort digitalis is most efficacious. The actual mode of supplying the necessary digitalis will greatly depend on the degree of urgency of the symptoms. If the patient is in a condition of gross congestive failure, it may not be justifiable to wait the necessary number of hours or days to produce slowing by oral administration. Frequently, patients in this extreme condition of heart failure are vomiting and are unable to retain anything given by the mouth. In such the most efficacious method of producing slowing of the ventricles is to give an intravenous injection of strophanthin, $\frac{1}{150}$ grain. This frequently produces a considerable slowing within half an hour, and it may be repeated if slowing is not obtained at the first injection. If the case is less urgent, digitalis may be administered by mouth.

There is considerable choice of preparations, but it is advisable for the practitioner to accustom himself to the use of one preparation, so that he knows exactly what results to expect from it; it is seldom that the pharmacopoeial tincture of digitalis fails where any other preparations would succeed. Slowing of the ventricular rate can be achieved within a few hours by giving ½-drachm doses of the tincture every hour, the total amount usually necessary being about 3 drachms. In the average case 20 minims of the tincture every four hours is sufficient to obtain slowing on the third or fourth day, by which time the patient has had 4 or 5 drachms. Vomiting, excessive slowing and coupling of ventricular beats are indications that digitalis ought to be temporarily withheld.

Patients are most comfortable if the rate, counted at the apex for a full minute, is between eighty and ninety. Seventy is too slow, as this rate would imply some excessively long diastolic periods followed by unpleasant bumping after the longer diastoles. Once the rate of the heart in mitral stenosis has been brought under control by means of digitalis, the rate should be kept constant between eighty and ninety with a maintenance dose of digitalis. The amount of digitalis necessary to attain this object varies in individuals, and usually the patients themselves quickly discover how many doses per day or per week are necessary to keep them in comfort. There are those who need only one or two doses per week; others will still require a 20-minim dose of the tincture three times a day. Each individual will find out for himself the necessary dosage. It is very seldom wise to attempt to restore a regular rhythm in this type of case with quinidine, and it certainly should never be attempted if the heart is obviously enlarged.

Thyrotoxic type

Increasing experience makes it certain that the proper line of treatment in all thyrotoxic cases of auricular fibrillation is subtotal removal of the gland. Before operation the rate can frequently be controlled by the administration of digitalis, though patients with thyrotoxicosis are less tolerant of digitalis than are rheumatic cases. In a considerable proportion of cases a normal rhythm is re-established within hours or days after operation. If auricular fibrillation is still present a fortnight after the operation re-establishment of the normal rhythm should be attempted by the administration of quinidine sulphate.

Myocardial type

In cases with high blood-pressure digitalis should be administered to produce the necessary slowing, and treatment for the high blood-pressure attempted. These cases are frequently very unsatisfactory in their response to digitalis. In those older patients suffering from auricular fibrillation with little enlargement of the heart and no abnormal rise in blood-pressure, quinidine finds its chief use, and in their cases once the rhythm is regularized a normal cardiovascular system can be restored. For this purpose the simplest method of administering quinidine sulphate is by a daily increasing dosage. On the first day the patient should be given 6 grains, on the second day two doses at a two-hourly interval, on the third day three doses; and on each succeeding day one dose is added at two-hourly intervals until normal rhythm is re-established. The days on which the rhythm is most likely to become regular are the sixth or seventh day, when the dosage has reached about 40 grains in the day. It is advisable to continue with a daily dose of quinidine sulphate, 6 grains, for some weeks after the restoration of a normal rhythm.

If, as often occurs, the rhythm reverts to auricular fibrillation, quinidine therapy by the above method must be repeated, though after three relapses it is usually futile to persist. The rate of the ventricles in the accepted and permanent condition of auricular fibrillation should be controlled by administration of the necessary amount of digitalis.

8.–VENTRICULAR FIBRILLATION

85.] The muscle of the ventricles may show the same incoordinate and irregular contraction which characterizes fibrillation of the auricles. This condition is comparatively common in the experimental animal, and can be demonstrated in cats after chloroform anaesthesia and an injection of adrenaline hydrochloride. Massage of the cat's heart will frequently restore a normal rhythm. A similar condition is probable in the human heart in some deaths from chloroform anaesthesia. Dying human hearts have infrequently shown ventricular fibrillation towards the end. It is certain that this condition cannot persist for any length of time without death. Some instances of paroxysmal ventricular tachycardia may merge into ventricular fibrillation.

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ARSENIC POISONING

See DERMATITIS DUE TO INJURY AND POISONING;
DRUG ERUPTIONS; *and*
TOXICOLOGY: HOMICIDAL, SUICIDAL, AND ACCIDENTAL POISONING

ARTERIAL DISEASE AND DEGENERATION

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ANEURSYM
APOPLEXY
BLOOD-PRESSURE, HIGH AND LOW
BRAIN: VASCULAR DISORDERS
CERVICAL RIB
SYPHILIS

1.–THE MECHANISM OF THE ARTERIAL CIRCULATION

86.] In considering the local and general effects of diseases of arteries it is well to review some fundamental conceptions. A muscular organ, the heart, by its inherent force of contraction pumps its contents into the arteries which are musculo-elastic tubes serving to transmit blood to their terminal ramifications. By virtue of their resiliency the elastic coats of the larger arteries absorb the intermittent shock of the blood propelled from the heart and convert an intermittent into a continuous stream. The arterioles leading from the smaller arteries to the capillaries may be regarded as taps which regulate the amount of blood flowing to various capillary networks or beds where part of the liquid component of blood (lymph) transudes for the nutrition of the tissues. On the distal side of the network venules and veins carry the blood back to the heart and together with lymphatics are also responsible for the return, after absorption, of the lymph.

Arterioles are composed chiefly of muscle and it is by their contraction and relaxation controlled by vasomotor nerves that the proper amount of blood can be requisitioned for the needs of the moment. If all the capillaries of the body dilated at the same moment it has been computed that a man would bleed to death into them within a minute or so. The vasomotor centre with its attendant nervous connexions forms an elaborate co-ordinating mechanism, so that blood can be switched over to organs requiring an increased supply while other areas become partially depleted. Though normally the majority of capillaries in the skin are open and their tone relatively stable, Krogh has shown that in the muscles the number of capillaries normally containing blood form but a fraction of the total number present, and the same appears to be true of other organs, such as the kidney. In such situations fluctuation in the number of patent capillaries takes place continually *pari passu* with changes in the functional activity of the part. Emotional pallor and blushing may be cited as instances of disturbance in the capillary circulation brought about by hormonal and nervous influences. Probably nervous disturbances are also responsible for vasovagal attacks (including so-called false angina), effort syndrome and other conditions formerly regarded as being cardiac in origin.

A spasmodic factor would appear to be present in such conditions as 'dead fingers', Raynaud's disease and some transient palsies; but when intermittent claudication occurs in a limb structural changes in the vessels should be suspected in addition to spasm, as spasm merely leads to an increased ischaemia of the muscles involved.

Arteries therefore are concerned not only with the transmission but also (acting under nervous control) with the regulation of the blood supplied to the tissues, and in conditions of disease both their structure and function are deranged. Particularly will disease modify the elasticity of the arteries. If the arterial system were rigid the pressure in the arteries would fall to zero between the beats and the flow would be intermittent. The mechanism maintaining a steady outflow through the arteries has been compared, not inaptly, to that of a scent spray. A scent spray is provided with a second bulb which by its elastic recoil ensures continuity of action, and with a nozzle offering resistance to the outflow. The elasticity of the aorta and arteries may be compared with the second bulb, while the muscular walls of the arterioles correspond with the nozzle. But for the continuous flow we should be conscious of intermittency at various nerve-endings, a phenomenon readily appreciated if amyl nitrite be inhaled. Persons suffering from arteriosclerosis whose arteries are more rigid than in health complain frequently of such throbbing sensations which often interfere with sleep. Sclerotic changes in the walls of the smaller arteries and arterioles increase the peripheral resistance to the blood-flow. A measure of this resistance is given by the diastolic reading of a sphygmomanometer. When the peripheral resistance is permanently increased a greater burden is thrown upon the heart, and if the circulation is to be maintained the left ventricle hypertrophies. The detection of hypertrophy distinguishes a case of permanently increased blood-pressure from one in which there is merely a temporary increase of pressure. In some instances the left ventricle is not equal to the task, and there may be, in spite of increasing peripheral resistance, a normal or even a low systolic pressure, a condition of serious augury. It is commonly thought that a high blood-pressure is evidence of arteriosclerosis. This, however, is not always the case. High blood-pressure can occur with supple arteries, and conversely, as will be seen later, arteriosclerosis may exist without high blood-pressure. The relationship between blood-pressure and arterial degeneration is not always easy to appraise; and extensive atheroma of the aorta may exist without the blood-pressure being raised. When the smaller vessels are affected by arteriosclerosis, the extent of the lesion appears to be the deciding factor. If the arteriosclerotic change is generalized the blood-pressure is likely to be high, and this will be true especially of the diastolic reading; but so great is the adaptability of other vascular areas that a high degree of arteriosclerosis may be met with in some restricted area of the arterial system without any obvious influence on blood-pressure.

From a physical standpoint the most important constituents of the arterial wall are the muscular and elastic tissues, the relative proportions of which vary in different positions. In the main primary channels, such as the aorta and its large branches, the elastic tissue predominates, whereas muscle is the more abundant in the smaller arteries, for example the radial and lingual. The elastic arteries are especially prone to atheroma (nodular arteriosclerosis) and to aneurysmal dilatation which supervenes upon syphilitic infection of their walls, whereas the muscular arteries are more susceptible to the diffuse forms of arteriosclerosis and in certain cases to primary calcification. Primary calcification must also be held responsible for important nutritive defects in the various organs and tissues supplied. Indeed when thrombosis completely occludes an artery necrosis of the part will result unless some other means of supply is available.

2.–FUNCTIONAL DISORDERS

Raynaud's disease

87.] Raynaud's disease affords the best example of the vasospastic group of vascular lesions. This disorder is characterized by vasoconstriction without organic disease of the arterial wall, and shows itself principally in the extremities although it also occurs in internal parts. The more or less persistent ischaemia, associated with passive hyperaemia, brings about disturbances of function and frequently ends in limited necrosis of the tissues at the extreme periphery of a limb. There appears to be an exaggerated response to the usual stimuli calling for vasoconstriction. The spasm may be excited initially by cold, although often of a degree that would not cause any such disturbances in a normal person. In the present state of knowledge it is impossible to fathom the underlying constitutional factor, that is to say, why, in certain persons only, cold or other exciting cause should produce spasm of peripheral vessels. Some believe that the internal secretions are in some way responsible, and the thyroid, the ovaries, and the adrenals have been incriminated, but further evidence is required before such hypotheses can be accepted.

Thrombo-angiitis obliterans

Several considerations suggest that thrombo-angiitis obliterans, at any rate in its earlier stages, should be included in the vasospastic group. Early in its course intermittent attacks of coldness and blanching of the feet are often induced by exercise. Cases occur in which pulsation in the posterior tibial artery is at one time distinctly felt, and at another absent. The improvement that may follow lumbar cord ganglionectomy is all the more significent when contrasted with the poor result of this operation in cases of atherosclerosis (see p. 51).

Ergot poisoning

Ergotism is another example of arterial spasm. In experimental ergot poisoning a functional arterial hypertonus can be maintained sufficiently long to produce well-marked intimal hyperplasia and mesial degeneration, terminating in thrombosis (Stopford). According to Telford and Stopford, when, as only rarely happens, a cervical rib produces gangrene of the fingers, this should be ascribed to pressure upon a portion of the cervical sympathetic which enters the arm in company with the lowest trunk of the brachial plexus, rather than to arterial compression. They point out that ligation of the subclavian artery is never followed by gangrene. To the resulting irritation thus set up they attribute the nutritional changes in the vessel wall and in turn the final thrombosis (see CERVICAL RIB).

Whether diseased are more liable than healthy vessels to spasm is open to discussion. Allbutt considered the supposition a sort of clinicians' Mesopotamia—a comfortable and useful doctrine entirely lacking in proof. If not occurring more readily in diseased vessels it would seem to be true that a spasm would occur with more effect in vessels already degenerate, and the intolerable although short-lived pain of angina pectoris is by many clinicians still regarded as the effect of coronary spasm, some holding that arterial spasm in itself is exquisitely painful, others falling back on the ischaemia of the heart-muscle which such a spasm induces, as the more probable explanation. The likelihood of coronary spasm being the underlying cause of pseudo-angina would seem to be even more doubtful. It is the prevailing fashion to regard pseudo-angina as one of the possible expressions of a vasovagal attack, but as the essential nature of vasovagal attacks is not yet clear the solution has still to be unravelled (see p. 642).

3.–ACUTE ARTERITIS

Primary and secondary arteritis

88.] The wall of an artery may become infected (1) from without, by the extension of some infective and inflammatory process (secondary arteritis), (2) from within, as occurs when an infective embolus lodges in the vessel, (3) through the vasa vasorum. The two latter are often referred to as primary arteritis.

(1)—Secondary Arteritis

When the artery is infected from without, the first change is a periarteritis in which the adventitia shares. Such a condition is usually referred to as a secondary arteritis and is seen in the neighbourhood of ulcerative processes such as occur in the walls of tuberculous cavities or in the floor of a gastric ulcer. The inflammation extends through the thickness of the wall, and a plastic endarteritis results. This is characterized by considerable proliferation of the subendothelial connective tissue whereby the internal coat becomes enormously thickened and the lumen of the vessel greatly diminished in consequence. This lesion, which represents the ordinary reaction of the vessel wall to an irritant and is often accompanied by thrombosis, is sometimes regarded as a protective mechanism preventing haemorrhage which would otherwise occur from erosion of the vessel wall.

Acute arteritis without suppuration may follow the application of radium or X-rays to a malignant growth. While the chief effect of this treatment is exerted directly upon the cells of the tumour, the acute arteritis and thrombosis induced play a subsidiary part in cutting off the blood-supply to the neoplasm.

(2)—Primary Arteritis

Following embolism

When an infected embolus becomes impacted in an artery, as may occur in infective endocarditis, the resulting infection leads to such weakening and softening of the wall that a mycotic aneurysm results. Rupture of such an aneurysm on a cerebral vessel may lead to fatal cerebral haemorrhage.

Following infection

Excluding embolic arteritis, the commonest clinical form of acute arteritis occurs in connexion with the infective fevers. Typhoid and influenza hold the chief place, but even in these diseases acute arteritis is very rare. In acute arteritis in scarlet fever the middle coat is particularly implicated, and necrotic foci have been found in this situation. Infection would appear to have reached the vessel through the vasa vasorum, and in some cases of acute arterial disease embolic processes in the vasa vasorum appear to be responsible. It is a moot question whether or not infection may also take place by way of lymphatics and directly through the blood-stream. In direct infection from the circulating blood within a vessel the intima is likely to be primarily infected, and Osler referred to the occurrence of small vegetative outgrowths such as are seen on the intima of valves, but stated that this is rare. Organisms have been found in the vessel wall in typhoid, pneumonia, and diphtheria cases.

Following rheumatism

That acute rheumatism sometimes attacks arteries is shown by the occurrence of inflammatory lesions of a subacute or chronic type in the aorta and larger arteries, where Aschoff's nodes have been found in the adventitia. More often there is a perivascular lymphocytic infiltration of the vasa vasorum extending into the middle coat and followed by fibrosis. The aorta, carotids, axillary and brachial arteries are said to be most frequently attacked.

Following typhoid

When acute arteritis complicates typhoid fever the arteries of the leg are most frequently involved and the lesion is usually unilateral. According to J. D. Rolleston the arteries most often involved are, in order of frequency, the posterior tibial, femoral, popliteal, anterior tibial, and dorsalis pedis. It occurs late in the disease or during convalescence.

(3)—Clinical Picture

Acute arteritis is manifested clinically by pain, often of great severity along the course of the vessel, and the affected limb becomes numb.

There is first diminution and then disappearance of the arterial pulsation below the level of the lesion. There is an increase of pyrexia, and swelling (sometimes accompanied by redness) over the vessel can be made out. Soon the limb becomes pale and cold, gradually becoming mottled, cyanosed, swollen, and finally gangrenous. In other cases, after an acute onset and symptoms suggesting that gangrene will ensue, the colour returns to the limb through the establishment of a collateral circulation. It is not always easy to distinguish between thrombosis due to a primary arteritis and that due to embolism. Sudden onset and the presence of conditions favourable to embolism make the latter the more likely.

(4)—Treatment

This is based on general principles. The limb should, as far as possible, be immobilized and kept warm, and if swollen may be slightly elevated. Opium may be necessary for the relief of pain, and glycerin and belladonna may be painted with due caution over the affected part. A careful watch will be kept for signs of gangrene and, should they appear, the ordinary principles adopted in the treatment of that condition should be applied. If local suppuration occurs, surgical intervention is likely to be imperative.

4.–PERIARTERITIS NODOSA

89.] An acute or subacute inflammatory disease of medium-sized arteries, characterized by sharply localized areas of exudation, degeneration, and proliferation in the mesial and outer coats of the affected arteries. Well-defined nodes result from these inflammatory processes, and secondary changes such as thrombosis or aneurysm may follow. As arteries in any part of the body may be affected bewildering clinical pictures may result. *Definition*

The cause is unknown. The character of the inflammatory changes suggests an infective origin. The condition may possibly be due to a filterable virus. There is no evidence that syphilis plays any causal part. *Aetiology*

The affected arteries are studded with nodular swellings varying in size from a pin's-head to a pea. Nodules of larger size are likely to be due to the formation of an aneurysm. The nodules are bluish or white in colour, and the arteries which appear especially likely to be affected are those of the heart, kidney, brain, and gastro-intestinal tract. Intravascular thrombosis is frequent, and infarction and other changes are produced in these organs following interference with their blood-supply. *Pathology*

Microscopic examination of a nodule shows inflammatory changes more especially in the adventitial and mesial coats. In the earlier stages these structures are infiltrated with polymorphonuclear and eosinophilic leucocytes together with varying numbers of mononuclear cells. At a later stage more or less fibrous replacement is seen. Changes in the intima never occur without involvement of the other coats, but leuco- *Inflammatory changes* cytic invasion may extend from these, and intimal proliferation with thrombus formation may occlude the lumen, or the walls may yield to form an aneurysmal dilatation, rupture of which may be fatal. The tissues immediately surrounding the affected portion of an artery are densely packed with leucocytes, and involvement of nerves in this periarterial inflammation may possibly account for the pain which is not uncommon.

Clinical picture

Owing to the varying distribution of the arterial lesions the clinical picture may vary. The disease occurs in early and middle adult life, but children are occasionally affected; it is five times more frequent in men than in women; it is usually ushered in with pyrexia and an unduly rapid pulse—wasting, weakness, anaemia, and leucocytosis being constant features; it usually proves fatal after a few weeks. As the temperature falls the pulse-rate fails to decline. Involvement of arteries supplying muscles causes muscular pain, weakness, and atrophy; and if the hand is involved it may resemble that of progressive muscular atrophy. When the arteries of the stomach and intestines are affected, severe colicky pain, nausea, vomiting, and diarrhoea may develop. With involvement of the renal arteries, symptoms of nephritis may appear with albumin, blood, and casts in the urine. When the coronary arteries are affected, symptoms of heart failure arise. Asthmatic manifestations with cough and haemoptysis have occurred with pulmonary involvement. Unfortunately nodules in the subcutaneous tissues of the trunk or extremities are seldom recognized; but strong presumptive evidence of the disease has led physicians to a biopsy of a portion of an affected muscle with the result that arterial and periarterial changes have been microscopically established. The blood shows a definite anaemia of secondary type with a polymorphonuclear leucocytosis and several cases have shown an eosinophilia. Blood-cultures are sterile.

Diagnosis

This grave affection is rarely diagnosed during life and may even escape detection at autopsy.

The disease behaves like a subacute infection. The variable clinical picture makes diagnosis very difficult and this can only be made with certainty when a subcutaneous node is discovered and submitted to microscopic examination.

Prognosis

The disease is usually fatal within a few weeks of onset, but in rare instances life has been prolonged for more than a year with remissions from time to time.

Treatment

Treatment can be only symptomatic.

5.–THROMBO-ANGIITIS OBLITERANS (BUERGER'S DISEASE)

(1)—Definition

Incidence

90.] This disease is almost invariably first seen in the legs. It is pre-eminently a disease of the male, less than 1 per cent of its victims being women. It is difficult to determine the average age of onset because patients rarely come for treatment till crippled by intermittent claudication, and it has probably taken many months or years to reach this stage. The age of Buerger's patients ranged from 17 to 56 years, and he stated that the average age was about 32. The onset of intermittent claudication after 50 is usually due to occlusion of an atheromatous artery, a condition which sometimes complicates thrombo-angiitis obliterans.

(2)—Aetiology

Suggested causes

The cause is unknown. Sometimes a history can be obtained of repeated or prolonged exposure to wet and cold, but this is probably only a contributory or aggravating factor. A striking number of cases, however, have occurred in men on active service during the War. Among suggested causes are tobacco, bacterial infection, changes in the viscosity and coagulability of the blood, reduction in blood-volume, carbon monoxide poisoning, and fly bites. Numerous cases have occurred in young Jews who were heavy smokers. In a series of 69 cases of thrombo-angiitis obliterans the blood-volume was found to be reduced on an average by 21 per cent, as compared with the average blood-volume in 22 healthy controls and 9 persons affected with arteriosclerosis. An interesting experiment of Buerger's supports the infective theory. He reproduced the condition in a patient, who had previously suffered from the disease but had remained free from symptoms for some years, by injecting into the perivascular tissues the clot and intimal scrapings from a vein of another patient (1929).

Tobacco

(3)—Morbid Anatomy

Microscopically the arterial walls show inflammatory changes which often extend into the surrounding tissues. In the course of time the perivascular tissues are converted into a sort of fibrous feltwork in which both nerves and veins may be embedded. The inclusion of nerves may account for the severe pain which is present even at rest in some cases, a condition often referred to as 'rest pain'. This periarterial fibrosis varies; exceptionally it is almost absent, in other instances it is so great that isolation of the individual vessels and nerves by dissection becomes impossible, the vascular and nervous structures forming one dense rigid cord.

Buerger, from his study of forty-five amputated lower extremities, concludes that the essential lesion is not primarily a progressive occluding endarteritis as had formerly been supposed. According to his view the condition may be considered in two stages: (1) the stage of acute inflammation followed by occlusive thrombosis, and (2) the stage of healing or organization. In the first stage all the coats of the vessel and the perivascular tissues become infiltrated by polymorphonuclear leucocytes. The lumen of the vessel at this site becomes completely filled with red clot. In the peripheral portion of the clot he found that larger or smaller foci of leucocytes (purulent foci) begin to form and these continue to increase in size by further immigration of

Stage of thrombosis

leucocytes. Miliary foci, not unlike tubercles, containing giant cells, are also stated to occur in the edge of the thrombus when organization begins. A thrombus, round below and cone-shaped above, occupies the affected artery for a length of from 5 to 10 centimetres. Sometimes a fine channel is visible running longitudinally in the clot through which it is often possible to squeeze a little blood. Similar changes, according to Buerger, are found in veins when they are involved. In the healed or organized stage there is a total obliteration of the lumina of arteries and veins by connective tissue. This obturating connective tissue usually contains numerous small vessels and vascular sinuses, thus giving rise to the fenestrated or cribriform appearance seen on microscopic section of the affected artery or vein. Buerger considered that when the canalizing vessel becomes excentrically placed and is sufficiently large, it has led to a mistaken interpretation of the histological appearances as being those of an endarteritis obliterans. Elastic-tissue stains show that the region of the organized clot is almost completely free from elastic tissue, and when a small amount is present it is concentrically arranged about the newly formed vessels. This is in marked contrast to the abundant elastic-tissue formation occurring in arteriosclerosis. In cases uncomplicated by arteriosclerosis the arterial wall above and below the site of thrombus formation is healthy. Indeed, it is common even in severe cases to find several inches of healthy vessel wall between two points showing partial or complete occlusion.

Stage of healing

The site of the obstruction influences the severity of the disorder. Obstruction of the upper part of the popliteal artery is particularly unfavourable. Occasionally a return of pulsation in an affected artery has been noticed and in most cases can be explained by increased circulation through collateral channels whereby anastomoses are opened up, and blood directed into the artery below its point of obstruction.

Telford and Stopford, unlike Buerger, find nothing of a typical character in the organization of the clot and they have only occasionally seen the leucocytic foci which he has so strongly emphasized. They agree with the earlier observers that the primary change occurs in the inner coat where proliferation of the intima can be invariably demonstrated at the initial site of the disease. In veins they found that proliferation of the intima is usually absent, the primary change being obstruction by clot which later becomes slowly organized.

(4)—Clinical Picture

Some patients give a history of an initial coldness of the feet coming on in attacks and accompanied by pallor of the part affected. This suggests that in the earliest stage of the disease vasospasm is the chief feature. Most patients first complain of intermittent claudication—namely, that after walking some distance they experience such severe and crippling pain in the calf of the leg or in the foot that they are obliged to stop. This cramp-like pain when in the calf of the leg is associated with a sense of rigidity and constriction. After they have stood still

Intermittent claudication

for a minute or two the pain dies away, only to appear again when they have walked a short distance. As the result of hurrying or walking uphill the pain comes on sooner. As the disease progresses the walking distance progressively diminishes: pain comes on after a distance of ten yards, whereas formerly 200 yards could be covered. Although in the long run both legs are affected, one leg is worse than the other. Not infrequently the leg in which the pain was first felt may eventually become the better of the two. It is usually found that pain, which at first was experienced only after walking, becomes severe and excruciating even in periods of rest—the so-called 'rest pain'. During recumbency the greatest comfort is often experienced with the feet in the dependent position, and patients will often try to get to sleep with the leg hanging out of bed. The constantly recurring pain permits little sleep, the sufferer becomes worn out and is a prey to intense mental depression. To quote Buerger: 'A haggard look, the staring eyes, the trunk bent with arms clasping and embracing the knee and leg of the affected part, is a striking and well-known picture. Or the foot is held tenaciously, the sole and dorsum rubbed and stroked in fruitless unavailing attempts to mitigate the intensity of the pain. . . . The pain, the disability, the threat of gangrene aroused by a knowledge of the fate of fellows in distress, so pervades every thought and action of certain cases as to cause complete demoralization, and in a few instances has led to attempts at suicide.'

'Rest pain'

Buerger's description

On inspection the feet are seen to be dead-white from ischaemia or dusky from cyanosis. If a patient is placed in a recumbent position, some degree of redness is induced by allowing the feet to hang down, while elevation above the horizontal will cause distinct blanching. The more rapidly these colour changes come and go, the more advanced is the disease. The feet are cold to the touch. In the worst cases it may be impossible to make out arterial pulsation at any point below Poupart's ligament. The popliteal artery can be palpated most efficiently by flexing the leg on the thigh while the patient is lying prone. Not only may it be impossible to feel arterial pulsation, but in some instances deep thickening due to the existence of a perivascular fibrous mass may be made out. The posterior tibial artery can be best palpated where it becomes superficial behind the internal malleolus, and the dorsalis pedis artery along a line passing from the middle of the front of the ankle joint to the hinder end of the first interosseous space.

Onychia

At a later stage, onychia, superficial thrombophlebitis or gangrene occurs; onychia commonly involves the great toe, and when its true significance as a pre-gangrenous condition has not been appreciated and the nail removed, a painful intractable ulcer occupying the nail bed results and may be accompanied by the most exquisite tenderness. Superficial thrombophlebitis of the legs (or of the upper extremities) occurs in from 20 to 25 per cent of the cases. Sometimes early in the course of the case, attacks of migrating phlebitis appear, and the true nature of the malady may remain unsuspected. According to Buerger, microscopic examination of the affected superficial vein after excision will frequently

Thrombophlebitis

reveal the typical pathognomonic lesions upon which a correct diagnosis may be based. Not only do the superficial veins present the typical miliary giant-cell foci, but they also demonstrate that these foci are a later stage, or attempt at organization, of purulent foci.

Gangrene

The development of gangrene is usually a slow process, passing through the stages of superficial necrosis, ulceration, and then gangrene, perhaps of one toe at a time with involvement of the forepart of the foot. Gangrene, though occasionally dry, is usually of the moist type. Occasionally the change is rapid, several toes becoming extensively gangrenous within a few days. If the case is first seen when gangrene is well established, the clinical picture is confusing, simulating gangrene from embolic, thrombotic, and arteriosclerotic processes.

(5)—Differential Diagnosis

Thrombo-angiitis obliterans has sometimes been mistaken for those relatively mild cases of sciatica or neuritis in which paroxysmal attacks of pain are evoked by walking. In these cases the pain lasts for a longer time than does the pain of intermittent claudication, and tenderness over the sciatic nerve should make the diagnosis clear. In tarsalgia and metatarsalgia pain localized in the foot may follow walking. There is usually a localized area of tenderness and absence of the vascular phenomena of thrombo-angiitis obliterans.

From arteriosclerosis

The chief difficulty of diagnosis is to distinguish between gangrene due to thrombo-angiitis obliterans and that of arteriosclerosis. The arteriosclerotic cases usually occur later in life. Blanching on elevation of the limb above the level of the heart, with redness on allowing the limb to assume the dependent position, is likely to be more prominent in thrombo-angiitis obliterans; and in arteriosclerosis the gangrene is likely to be more acute.

(6)—Treatment

When seen in its early stages or in cases ushered in with migrating phlebitis, the importance of diminishing the functional demands on the circulation in the affected parts is evident. If thrombo-phlebitis is present complete rest is absolutely necessary. In other cases prolonged standing and walking must be prohibited. Exposure to cold must be avoided and anything like tight shoes or sock suspenders, which by compression produce local anaemia, should be discontinued. When intermittent claudication has appeared, many patients will be willing to give complete rest a trial for a few weeks, and during this time postural treatment as recommended by Buerger may be employed. It aims at increasing the blood-supply to the affected limb by periodically flushing the limb with arterial blood by alternately raising and lowering the leg. Buerger's procedure is as follows: 'The affected limb is elevated with the patient lying in bed, to from 60° or 90° above the horizontal, being allowed to rest upon a support for from 30 seconds to 3 minutes, the period of time being the *minimum* amount of time necessary to produce blanching or

Buerger's postural treatment

ischaemia. As soon as blanching is established, the patient allows the foot to hang down over the edge of the bed for from two to five minutes, until reactionary hyperaemia or rubor sets in, the total period of time being about one minute longer than that necessary to establish a good red colour. The limb is then placed in the horizontal position for about three to five minutes, during which time an electric heating pad or a hot-water bag is applied, care being taken to prevent the occurrence of a burn. The placing of the limb in these three successive positions constitutes a cycle, the duration of which is usually from six to ten minutes. These cycles are repeated over a period of about one hour, some six to seven cycles constituting a seance. The number of seances cannot be categorically stated, but should vary with the case. In a general way they should occupy at least six to seven hours a day, that is, every alternate hour, during the daytime. During the hours of rest heat is applied continuously in the form of an electric pad, hot-water bag, hot air apparatus, or electric lamp.'

Sodium citrate

Radiant heat is not well tolerated in the presence of migrating phlebitis. Improvement sometimes follows attempts at diminishing the viscosity of the blood by the intravenous injection of sodium citrate. The patient is kept in bed for the first month of treatment, and 250 c.c. of sodium citrate solution (1 per cent) is given intravenously every second day. During the second month a similar amount is given every third or fourth day, and the patient is allowed to sit up in a chair with the legs dependent for a short time each day. During the succeeding months the injections are given at intervals of a week, ten days, a fortnight, and an increasing amount of exercise is permitted.

Analgesics

For the relief of pain aspirin, phenobarbitone (luminal), or tablets of aspirin 4 grains, phenacetin 4 grains, codeine phosphate $\frac{1}{6}$ grain (i.e. veganin) may be employed, but they usually fail and morphine may have to be temporarily employed. The injection of absolute alcohol is inadvisable. Temporary relief to the sufferer is sometimes afforded by theominal (theobromine 5 grains, luminal $\frac{1}{2}$ grain), one tablet being given three or four times a day. Lacarnol (extract of heart muscle), one ampoule daily intramuscularly, and acécoline (acetylcholine hydrochloride), 0·02 to 0·2 gram (dissolved at the time of use in 5 c.c. of water) daily by injection, are also employed.

Operative treatment

Operative treatment of various kinds has been practised in the hope of avoiding amputation, but most have failed to substantiate the claims made for them. Among such may be mentioned partial adrenalectomy, perivascular sympathectomy, and ligature of the femoral vein. The best results appear to have followed lumbar cord ganglionectomy (excision of 2nd, 3rd, and 4th lumbar ganglia with the connecting chain). According to Telford and Stopford, of 42 patients operated on between April 1931 and April 1934, and alive in April 1935, 25 were free from rest-pain, were able to walk well, and in most instances had returned to work; 7 showed improvement as regards rest-pain and general condition, but little or none as regards walking and capacity for work; 10 showed no improvement; and several at a later date submitted to amputation. As the object of ganglion sympathectomy is to bring about dilatation of such collaterals as are still capable of enlargement and to do away with spasm, it is clear that the best results will be obtained in younger patients in whom the condition is not very far advanced.

Prognosis when gangrene is present

Where gangrene is present the outlook is not good, but cases with onychia have shown permanent healing. In most cases intermittent claudication is not abolished although the walking distance is often considerably lengthened. Ganglion sympathectomy is not likely to be helpful in cases in which arterial thrombosis is secondary to atheroma. In deciding whether lumbar cord sympathectomy is likely to be beneficial or otherwise, observations of the skin temperature are made with an electric surface thermometer before and after the injection of a spinal anaesthetic. The resulting rise of temperature, occasioned as it is by the improved circulation through the part, serves as an indication of the improvement that may be expected from the operation. In a healthy subject the rise of temperature in the skin of the foot may reach 10° C. In one of Telford's cases of thrombo-angiitis obliterans the temperature rose 5° C. in the left foot and only 0·8° C. in the other. Four months after operation the patient could walk any distance if he went slowly, but if he hurried he experienced pain in the right calf. He regarded the left leg as completely well.

Amputation

Amputation in this condition has usually to be performed through the lower third of the thigh, but the level will depend upon the site of occlusion. Gangrene of the flaps is likely to occur if too low a level is chosen.

6.—CHRONIC ARTERITIS

(1)—Definition and Classification

91.] Under this heading the following conditions may be considered, with the reservation that the term chronic arteritis is not to be taken too literally as many of the changes are degenerative in nature: (1) atheroma (nodular arteriosclerosis, atherosclerosis, endarteritis deformans), (2) arteriosclerosis, (3) arteriolosclerosis (essential hypertension), and (4) Mönckeberg's sclerosis.

Although atheroma of the large elastic arteries may occur alone, it is quite commonly accompanied by arteriosclerosis of the muscular arteries, and in the latter case arteriolosclerosis is usually present in addition. The changes in the arteries produce their effect by leading to a loss of elasticity, and the hyperplasia brings about a diminution in the lumen of the vessels; occlusive thrombosis may also occur.

'Ageing' of arteries

The changes that take place in the structure of arterial walls as age advances make it difficult in some cases to say whether an artery is the seat of a pathological sclerosis or is merely an 'old' artery. This is particularly true of the smaller arteries and hardly applies to the aorta. From early childhood there is, in the case of the aorta, a gradual increase in connective tissue until the three layers of the intima distinguishable in adult life are fully established. The middle coat of the aorta consists largely of elastic tissue and contains relatively little muscle, and this proportion persists throughout life. According to Schultz a study of the elastic tissue of an aorta which has been stained by kresyl is sufficient for one adequately experienced to permit a judgement of the age of the patient. Arteries are under constant longitudinal tension and they shorten when removed from the body. By the end of the fourth decade, however, they have undergone sufficient stretching to eliminate this longitudinal tension, and in old age they are both elongated and dilated to such an extent that they are distinctly tortuous.

Splitting of internal elastic lamina

In the muscular arteries a tendency is noticeable from early youth to splitting of the internal elastic lamina, and this becomes more and more striking with advancing age. In this way two or three new laminae may be developed in the intima while newly formed fibrous tissue fills up the interstices between them. As arteries grow there is also a considerable development of new muscular tissue in the media. Later in life a progressive fibrosis of the media takes place, and it is doubtful whether this is to be regarded as entirely physiological. That is, a definite criterion is lacking by which physiological change can be distinguished from pathological sclerosis. Furthermore, as elastic tissue increases during childhood, it would appear that increase of elastic tissue in adult life must not be attributed solely to increase of blood-pressure.

Atheroma

In each vascular region the pathological processes under discussion assume a form peculiar to that region. Thus, atheroma affects the aorta, the main branches of the aorta including the coronary arteries, and also the arteries of the brain. In the large arteries of the lower extremities the process takes quite another course, possibly because the functional strain exerted is different. It is suggested that the predominance of calcinosis in Mönckeberg's sclerosis, a degenerative condition affecting the arteries of the lower limbs, is conditioned by the alterations in blood-pressure which accompany changes in the position of the body. The other muscular arteries are especially liable to a fibrosis exemplified by arteriosclerosis in the narrower sense of the word, and the same is true of the arterioles.

Calcinosis

Fibrosis

(2)—Aetiology

The chief causes appear to be the wear and tear of life, all conditions leading to increased blood-pressure, acute infections, and intoxications. With regard to the first of these, the walls of the aorta are subjected to a distending force of 25 pounds to the square inch about 72 times a minute even when the body is at rest. Osler pointed out the advantage therefore of being born with arteries of good quality, many individuals and families being badly handicapped in this respect. Modern urban life with its constant rush and incessant strain, with its leisure too often spent without relaxation, are highly favourable to the development of

Heredity and environment

arteriosclerosis. As life advances over-eating, over-drinking, and curtailment of hours of rest add their quota. Race, climate, environment, occupation, and diet have all to be considered as aetiological factors affecting blood-pressure. Athletes and those engaged in laborious occupations are especially liable. Of all the infections, syphilis is outstanding in its predilection for arteries; the other fevers fall far behind, but statistical studies show that arteriosclerosis is more frequently met with in persons who have suffered from typhoid fever than in those who have escaped infection. As already mentioned foci of infection in the walls of arteries may be set up by influenza, scarlet fever, and diphtheria.

Infections

Exogenous and endogenous poisons

Of the exogenous poisons, lead, alcohol, and tobacco appear to be the chief. Of endogenous poisons arising from perversions of metabolism, it is sufficient to point out the frequency of arteriosclerosis in diabetes mellitus, gout, obesity, and chronic nephritis. According to Joslin the most common cause of death in diabetes mellitus, since insulin treatment has become prevalent, is arteriosclerosis rather than coma.

(3)—Pathology

(*a*) *Atheroma*

Atheroma in some degree is almost universal in persons over thirty years of age. It affects elastic arteries and is seen especially in the aorta and its branches, including the coronaries, and in the arteries of the circle of Willis. It appears to affect points of maximal strain, and patches are often related to the orifice of branches such as those of the intercostal and lumbar arteries. It should not be confused with the subintimal fatty streaking common in the aorta of quite young subjects, which is more properly regarded as a lipoid infiltration without microscopic evidences of local disease.

In atheroma the changes are confined at first to the intima. Starting primarily and always more advanced in the deeper layers, it is doubtful whether the earliest change is proliferation of the connective-tissue cells, which then undergo fatty change, or whether fat is primarily deposited in the ground substance of the interstitial tissue, possibly in connexion with degenerating elastic tissue. Ophüls believed that fat droplets are first formed within the cells, and that as the latter disintegrate the fat becomes widely scattered in the interstitial tissue. In any event, a small white nodule forms under the endothelium, and proliferation and degeneration go hand in hand. If the superficial part of the patch, which consists of proliferated laminae of connective tissue, be cut through, an accumulation of fatty degenerate material will be found in the deeper part, the whole forming the atheromatous abscess of the older writers. Later the muscle-cells of the inner layers of the media may be filled with fat droplets. By the giving way of the endothelium covering the nodule an ulcer is formed, and the fat, which is liquid at the body temperature, is swept away into the circulating blood. In other cases lime salts are deposited within the nodule, and a calcareous plate results. In advanced cases the inner surface of the aorta becomes rough and irregular from the presence of these calcified plaques and ulcers, and where the middle coat is also weakened an aneurysmal dilatation may follow. Sometimes by the projection of a calcareous plate the endothelium is ruptured, and blood finds its way beneath the plate, giving rise to a dissecting aneurysm. An aneurysm arising as a result of atheromatous change is much rarer than in syphilitic aortitis, in which the middle coat is primarily and extensively involved. Clinically, it may be possible to say that an aneurysm is of atheromatous origin, as opacities due to calcification may be detected in the wall on X-ray examination, and the patient's blood fail to give a positive Wassermann reaction. Gangrene in diabetes mellitus is associated with atheroma in the arteries of the leg whereby their lumen is narrowed.

Dissecting aneurysm

(*b*) *Arteriosclerosis and Arteriolosclerosis*

Perhaps no subject in the whole range of pathology admits of such diversity of opinion as that of arteriosclerosis. Quite apart from the question whether it causes or is due to high blood-pressure, controversy still continues over the morbid processes involved, whether there is a true hypertrophy of muscle fibres, and, if such exists, whether toxic and pressor substances in the blood lead first to a spasm of the smaller vessels, and whether increased viscosity of the blood is in any way responsible. A critical survey of these questions is outside the scope of this article, and it is proposed to adhere to the views current among a considerable number of teachers.

A diversity of theories

An individual in middle life with a high blood-pressure usually has tortuous and thick radial and temporal arteries and hypertrophy of the left ventricle, and may die either from cerebral haemorrhage or heart failure. The enlargement of the left ventricle and the thickening of the larger arteries are examples of work hypertrophy; they are not the essential lesions of the disease but are to be regarded as an effect rather than the cause. These thickened vessels show diffuse thickening and hardening, a lumen usually wider than normal, an increase in length, and distinct tortuosity. Microscopically the inner coat is definitely thickened by overgrowth of fibrous tissue, and the elastic tissue is increased in amount; the internal elastic lamina has split and reduplicated; and by the time death has occurred it is already broken up. The middle coat is largely fibrous, and the muscle after undergoing an increase in bulk has undergone replacement fibrosis. There is a generalized hyperplasia of the arterial musculature which is the result of an increased resistance to the passage of blood through the arterioles. Arteriolosclerosis is the primary lesion although the aetiological factor involved cannot be regarded as settled and, although widespread, is not evenly distributed throughout the body. The arterioles of the kidneys are practically always involved and more severely than those elsewhere; those in the spleen, pancreas, liver, and brain are often affected, although less severely,

Association with high blood-pressure

Hyperplasia of the arterial musculature whereas the skin, skeletal muscles, myocardium, lungs, and gastro-intestinal tract are but slightly involved. The microscopic changes differ in some respect according to the size of the arterioles affected. One of the principal changes is the presence of hyaline substance beneath the endothelium. As the process advances the lumen becomes greatly narrowed and finally becomes completely obliterated. The effect of this change in the kidney is an ischaemic atrophy—not a nephritis—and is often termed primary contracted kidney. Clinically the term essential hypertension is commonly used to describe this type of case.

(*c*) *Mönckeberg's Sclerosis*

Mönckeberg's sclerosis is essentially a calcareous change affecting the middle coat of the muscular arteries. It attacks especially the arteries of the lower extremities. Men are more likely to be affected than women.

Age incidence

It is seldom seen before the age of fifty. Lime salts are deposited in the direction of the muscle fibres, with the result that a series of calcified rings may more or less completely encircle the vessel. At first the distribution of the rings is patchy, so that unaffected portions of vessel wall may intervene. At a later stage the intervening portions may become calcified, the artery for a considerable length being converted into a rigid calcareous tube. This form of calcification differs from that seen in atheroma, not only in its localization, but also in its microscopic appearance, though both types of change are sometimes seen in the same vessel. Fatty changes precede calcification in atheroma, but this is not usual in Mönckeberg's sclerosis. The earliest change appears to be a

Hyaline degeneration

sort of hyaline degeneration affecting both muscle-fibres and connective tissue, and subsequently lime salts are deposited in the form of fine granules which run together to form continuous rings. The clinical diagnosis of the condition can often be confirmed by X-ray examination. Bone formation may occur, and even red bone marrow has been observed in the bony interstices. The calibre of the affected vessels is sometimes increased, but only a fixed supply of blood can be transmitted, and when muscles are put into action intermittent claudication results. Owing to the diminished elasticity of the walls the blood-supply to distal parts is defective, and interference with nutrition results, while thrombosis may lead to complete occlusion and may be the determining cause of gangrene. Injury to the calf may rupture the brittle wall and produce a diffuse traumatic aneurysm.

Medial necrosis

In animals medial necrosis followed by calcification has followed the intravenous injection of adrenaline. That this is to be attributed to toxicity rather than to the rise in blood-pressure gains support from the investigations of Braun, who obtained similar results from the simultaneous injection of adrenaline and amyl nitrite, thus preventing any rise in blood-pressure. A similar condition has also followed the injection of nicotine, digitalin, diphtheria toxin and irradiated ergosterol.

(4)—Clinical Picture

Great mental and bodily vigour are common in the subjects of high blood-pressure, and it is often said that hyperpietics do the work of the world. Such mental and bodily vigour may persist even with a high degree of arteriosclerosis. If a person whose blood-pressure is unduly high is kept under observation it may be noticed that as the years pass what may be termed the basal systolic level gradually rises, and that definite fluctuations of pressure occur in times of stress. A fortnight's rest in bed often reduces a pressure of 190/110 to 160/100. A year or two later the pressure may have risen to 210/120. But now a fortnight's recumbency has less effect, and possibly produces a reduction to 190/110 only, this figure representing the basal level, as compared with that of 160/100 recorded after rest two years before. In such a case the physical signs indicate an increase in the amount of left ventricular hypertrophy and in arterial rigidity. The urine is likely to be abundant, pale, of low specific gravity, and to contain a trace of albumin. Sooner or later the sufferer becomes conscious that his mental and bodily powers are not what they were; his friends perhaps notice that he is becoming a little pale; he tires more easily and cannot concentrate, becomes forgetful and irritable, and perhaps loses weight. Some patients show neurasthenic manifestations, especially when insomnia is present. Attacks of nocturnal cramp are not infrequent, or cramp may occur after exercise. The skin is under-nourished and tends to become thin, dry, and wrinkled.

Rise of basal systolic pressure

Blood-pressure

Waning of mental and bodily powers

Allbutt gave the name of decrescent or senile arteriosclerosis to a group of cases in which the systolic blood-pressure may not be raised, or only very slightly, and the diastolic pressure is distinctly low. The pulse-pressure, or differential pressure (the difference between the systolic and diastolic readings), will therefore be high. (In a normal person the pulse-pressure is usually about one-third of the systolic reading.) This high pulse-pressure is helpful in the diagnosis of such cases, for as a rule the heart is not hypertrophied but may show evidence of myocardial inefficiency. In an established case there is dyspnoea on exertion, and the heart-sounds are of poor muscular tone, and tic-tac rhythm is present. These patients are liable to 'episodal crises' in which the systolic pressure may rise to over 200 mm. Hg with a corresponding increase in the diastolic reading. The crisis is manifested clinically by severe headache and is of short duration, but cerebral apoplexy or signs of cardiac failure may arise in connexion therewith.

Decrescent arterio-sclerosis

High pulse-pressure

As the disease advances symptoms will vary according to the relative distribution of the lesions and may be considered under the headings of cerebral, cardiac, and renal manifestations.

Finally it should be mentioned that arteriosclerotic changes often associated with atheroma are not infrequently responsible for senile gangrene.

(*a*) *Cerebral and Nervous Manifestations*

Transient giddiness is troublesome. It is especially likely to occur with sudden change of position and may be explained by diminished elasticity of the arteries. It may also accompany the episodal crises. Frontal headache often occurs and may be long continued. Far more alarming are the transient attacks of hemiplegia, monoplegia, aphasia, loss of vision or paraplegia. These attacks are sudden, and recovery is complete, though at the onset of the hemiplegic attack there may be nothing to differentiate them from the permanent form. The underlying cause is usually regarded as angiospasm although some regard the condition as one of serous apoplexy, in which on account of the high blood-pressure and degenerative change in the vessels plasma has exuded through the vessel walls. Epileptiform convulsions may occur. In the absence of syphilis and of chronic plumbism, convulsions occurring in persons of middle age should always arouse the suspicion of arteriosclerosis. Cerebral haemorrhage and thrombosis are frequent terminal events.

Transient hemiplegia

Convulsions

Ocular changes

Ocular changes are frequent; and apart from choked disc secondary to oedema of the brain, which does not differ ophthalmoscopically from that resulting from other causes of increased intracranial pressure, two varieties of hypertensive retinopathy are recognized: (1) retinal arteriosclerosis, (2) hypertensive neuro-retinopathy. In retinal arteriosclerosis the arterial walls appear as white streaks bordering the arterial blood column, which shows an irregularity of outline due to circumscribed constrictions and dilatations of the artery. In some cases arteriovenous compression can be detected. Uniform narrowing of the arterial blood-columns should not be regarded in itself as sufficient evidence of arteriosclerosis as it is also met with in the toxaemias of pregnancy and in acute glomerulo-nephritis before there has been sufficient time for definite thickening in the arteries to occur. Haemorrhages and sharply delimited white spots are seen in the retina. The papilla is usually normal. In hypertensive neuro-retinopathy the optic disc is affected. It is swollen, usually reddened, and with indistinct margins, so that it may be impossible to delimit the papilla from the adjacent retina, which is also swollen. A greyish clouding of the retina due to oedema can be distinguished, and white cottonwool-like areas are common, especially in the neighbourhood of the papilla. Later if not absorbed they become sharply outlined, bright and shiny, or yellow and densely opaque. Haemorrhages are commonly present from an early stage and are often flame-shaped. A great predominance of haemorrhages in one eye should arouse the suspicion of a blocked central vessel. Marked constriction of the retinal arteries is noticeable, so that there may appear to be fewer arteries than normal, and they cannot be followed far from the disc. When neuro-retinopathy develops in a long-standing case of hypertension, retinal arteriosclerosis is also likely to be present. It is quite common for patients with extensive changes in the retina to make no complaint about dimness of vision, because the macula is relatively unaffected. Sudden blindness due to the onset of hypertensive encephalopathy may occur; other complications include haemorrhage into various parts of the eyeball, detachment of the retina, occlusive thrombosis of the central artery or vein, and secondary glaucoma. Temporary paralysis of an eye-muscle sometimes occurs.

Mental changes

Gradual failure of the mental powers may culminate in dementia and may be associated with melancholia, periods of excitement, delusions, and mental vagaries of all kinds.

(*b*) *Cardiac Manifestations*

Atheromatous changes

The symptoms referable to the heart are usually due to interference with the nutrition of the heart-muscle. As already mentioned the left ventricle hypertrophies in order to meet the burden imposed upon it by the increased peripheral resistance. Atheromatous changes near the mouths of the coronary arteries in the first part of the aorta or in the walls of the coronary arteries are likely to interfere with the supply of blood to the myocardium, with the result that clinical manifestations of cardiac inefficiency arise. Dyspnoea, palpitation, and auricular fibrillation appear as a longer or shorter prelude to congestive failure. In another type of case, in which nocturnal attacks of 'cardiac asthma' or pulmonary oedema recur, left ventricular failure should be suspected.

'Cardiac asthma'

In other cases an attack of coronary thrombosis may be the first embarrassment experienced. In others attacks of angina pectoris may draw attention to the cardiovascular system. Heart-block and changes in contractility of the myocardium leading to pulsus alternans also occur in connexion with coronary disease (see Vol. I, p. 557).

Atheroma of the aorta

One type of case deserves notice in greater detail. A middle-aged man may complain of pain behind the upper part of the sternum which comes on with especial frequency if he starts to walk soon after taking a meal. If out in the street, he usually stands still and looks in a shop window so as not to attract attention. In a minute or two he is able to go on again, but has not gone far before the same thing happens again. He may say that he thinks it must be some form of indigestion because he sometimes gets relief if he brings up a little wind. The story is typical of atheroma of the first part of the aorta, in which the coronary circulation is becoming impeded, the attacks being comparable to those of intermittent claudication, in which narrowing of the arteries of the leg is present. Sometimes the attacks are spoken of as angina minor and are of serious import as they are not infrequently followed either by angina major (i.e. true angina pectoris) or by coronary thrombosis.

Arteriosclerotic changes may attack the valves of the heart. Apart from syphilis a sclerosing type of endocarditis affecting the aortic or the mitral valve is recognized. As the lesion is likely to be progressive the outlook, especially if the aortic valve is implicated, is very serious.

(*c*) *Renal Manifestations*

There are two groups of cases: (1) those in which primary disease of the kidney leads on to arteriosclerosis, (2) those in which a scattered schaemic atrophy of the renal substance takes place on account of arteriosclerotic changes in the arteries of the kidney.

In the first group very high blood-pressures are recorded, yet the patient is much more likely to die from uraemia or intercurrent infection than as a result of an arterial disaster. The presence of a high blood-urea figure will help when diagnosis is difficult, and, unlike what is seen in arteriosclerosis, death usually occurs before the age of forty-five.

Focal changes

In the second group, which includes cases of essential hypertension, although in the kidney degenerative vascular changes are constant, it must be realized that the changes are focal and that the secretory tissue between the atrophic portions is normal. Since 60 per cent of renal substance must be destroyed before renal inefficiency occurs, the heart usually fails before the kidney. As long as there is neither renal nor cardiac inefficiency the blood-urea remains within normal limits, or is but slightly increased, reaching from 45 to 85 mg. per 100 c.c. In the malignant phase of essential hypertension renal inefficiency becomes a prominent feature of the disease.

(5)—Diagnosis

This will be made on the presence of the cardinal features of the disease, namely, (1) thickening of the palpable arteries, (2) left ventricular hypertrophy, (3) high blood-pressure in the majority of cases, (4) visible changes in the retinal vessels, and (5) a slight and variable quantity of albumin in the urine. It is important not to mistake a full vessel for a thickened one. A small portion of the radial artery should be emptied of blood by compressing the vessel with one finger above and with another finger below and then palpating the artery between the two points of pressure. In senile arteriosclerosis there is neither an increase in blood-pressure nor cardiac hypertrophy, but the pulse-pressure is likely to be high, and the radial and other arteries thickened. A low blood-pressure may be found in early arteriosclerosis, and in advanced cases in which cardiac dilatation has followed an acute illness, or during intercurrent infections.

(6)—Treatment

General measures

Though no form of treatment can repair the arterial damage, it may be possible to retard the progress of the disease. It is in the early stages of the disease that such efforts are most likely to succeed. Hours of work should be reduced, and responsibilities shifted to other shoulders. It is not usually wise to suggest that the sufferer should entirely give up work, but he should work at lower pressure. One day a week in bed is not a bad prescription. All sudden effort likely to throw strain upon vessels should be avoided, but regular exercise tends to lower tension and relieve the heart. Much benefit may accrue from a protracted holiday, but it should be pointed out that rest in the open air if possible should be part of the daily programme. Walking, riding and golf in moderation are usually permissible. Reduction in the amount of food is of far greater importance than the avoidance of certain articles of diet, and a patient is well advised to get up from a meal feeling that he could have eaten more. 'Moderation in all things' is the watchword. Salt restriction has been advocated strongly, but it is doubtful if its general adoption is worth while. A diet deficient in salt is unpalatable to many persons and is likely in these cases to be followed by loss of appetite and a sense of bodily weakness if persisted in for any length of time. The best results of salt restriction are perhaps seen late in the disease when myocardial inefficiency is accompanied by oedema.

Salt restriction

As long as renal function is adequate there is no justification for the rigid restriction of protein. There is no objection to a little meat once a day and the temperate use of other protein food, although avoidance of substances particularly rich in purine bodies may be advisable. Protein restriction is sometimes carried to such extremes by the patient that anaemia and asthenia are superadded to his other troubles.

Protein restriction

Fluid should not be taken in excess, and in an incipient case it is probably as well to give up alcohol entirely. Some physicians advise home-made lemonade and orangeade in the belief that the continued taking of citric acid tends to decalcify the body. Sour milk has its advocates. A man who has been a heavy smoker will do well to moderate his allowance of tobacco and to avoid inhaling. The action of the skin should be promoted, and a warm bath at night and an occasional Turkish bath are helpful. Sojourn in a warm climate in the winter months, if possible, is of benefit. The bowels should be regulated, and in plethoric individuals a morning saline draught may be advised. Foci of infection should be looked for, and if discovered should be suitably dealt with. When obesity is present the usual means of reducing body-weight should be adopted but with discretion. Little can be done beyond symptomatic treatment when the disease is well established. There is some evidence that iodine prevents the progress of the disease, and it is usual to give potassium or sodium iodide in doses of 5 or 10 grains three times a day over prolonged periods. Iodides should be freely administered in all syphilitic cases. Drugs producing peripheral vasodilatation such as nitroglycerin, sodium nitrite, erythrol tetranitrate are widely used. Their therapeutic utility in arteriosclerosis is small apart from headache and episodal crises. In some instances they are found to intensify headache rather than relieve it. Sleeplessness may be relieved by 20 to 30 grains of sodium or potassium bromide, or by phenobarbitone (luminal), 1½ grains.

Fluids

Iodine

7.–SYPHILITIC ARTERITIS AND AORTITIS

92.] Syphilitic arterial disease exerts its paramount action on small vessels by causing endarteritis and periarteritis. Aortic lesions start in the vasa vasorum, and the changes are secondary to the morbid changes in these small vessels.

Syphilitic aortitis

The changes brought about by spirochaetal infection of the aorta are best studied in the case of a young subject in whom lesions due to atheroma are less likely to obscure the picture. The lining of the aorta is irregular, no longer smooth, and presents numerous pale grey translucent elevations and depressions taking the form of longitudinal furrows or of spider-like scars. The elevations result from hyperplasia of the intimal connective tissue, and their translucent appearance is due to hyaline degeneration. The depressions are the consequence of a mesaortitis, the intima being furrowed by the contraction of newly formed fibrous tissue in the middle coat. These processes are initiated by the activity of spirochaetes in the perivascular lymphatics.

Mesaortitis

The inflammatory change is first seen as a perivascular infiltration round the vasa vasorum of the outer coat of the aorta. The vasa vasorum themselves undergo a proliferative endarteritis which greatly narrows their lumen. The perivascular infiltration tracks along the vasa till the middle coat of the aorta is reached, where small patches of focal necrosis arise and interrupt the continuity of the circular elastic fibres. In the course of time these necrotic foci become replaced by fibrous tissue. Weakening of the aortic wall is in this way effected and aneurysmal dilatation rendered possible. Over these weakened patches in the media hyperplasia and sclerosis of the intima take place. The resulting elevations show no tendency to fatty or calcareous change or to ulceration, thus differing from atheroma which, however, may co-exist. Minute gummata are sometimes found in the media and lead to further weakening of the aortic wall. The first part of the aorta is most commonly affected, but any part may be involved although the abdominal aorta rarely shows signs of infection. The whole circumference of the first part of the aorta, sometimes for a vertical inch or more, may be affected. In some cases the mouths of the coronary arteries are partially occluded.

Sclerosis of the intima

Obliterative endarteritis frequently affects the smaller arteries, especially those of the brain. The process starts as a lymphocytic infiltration of the adventitia, spreads to the media and is associated with proliferative changes in the intima leading to narrowing of the lumen. Although syphilitic endarteritis can affect any part of the body it is only in the brain that it is likely to give rise to definite symptoms.

Treatment

For treatment see ANEURYSM, Vol. I, p. 520.

8.—COARCTATION OF THE AORTA

93.] This is the term employed to denote a congenital contraction of the aorta occurring at the aortic isthmus—that portion of the aorta intervening between the left subclavian artery and the point of junction of the ductus arteriosus. In foetal life most of the blood entering the pulmonary artery is conducted through the ductus arteriosus to the descending thoracic aorta. Two types of aortic coarctation occur.

The infantile type

In the first, known as the infantile type, the aortic isthmus is contracted throughout its length. It may be regarded as a persistence of the foetal condition. In foetal life this portion of the aorta has little work to do as blood enters the descending aorta largely through the ductus arteriosus. Should this portion remain hypoplastic after birth, and it is especially likely to do so if the ductus arteriosus remains patent, the infantile type of coarctation results. The hypoplasia may persist for a few weeks or months after birth, but it is rarely found in adult life. In extreme cases the isthmus may be replaced by a fibrous cord, the circulation to the lower part of the body being carried on by the development of a collateral circulation between branches of the subclavian artery above the constriction with intercostal arteries arising from the aorta below the constricted site.

Adult type

The second or adult type of coarctation consists of a more localized constriction of the aorta at or just below the insertion of the ductus arteriosus. It is unusual for the ductus arteriosus to be patent in this type; indeed it would appear that the condition commonly depends upon varying degrees of hyperinvolution of the ductus arteriosus, whereby the aortic wall becomes unduly encroached upon. The aorta above the level of the constriction is often dilated, and occasionally an aneurysm is present; but it may be narrowed below. The heart usually shows some enlargement of the left ventricle. A bicuspid aortic valve is the most commonly associated anomaly. The adult type of coarctation of the aorta is three times more common in males than females.

Symptoms

Except in the more severe types there may be few or no symptoms. Sometimes the condition is only recognized after the occurrence of some catastrophe. In a case seen by the writer rupture of the aorta occurred in a boy of fourteen after he had won a school championship at fives, in another case the condition was only recognized in a boy of eighteen after a cerebral haemorrhage had taken place. Intermittent claudication in the legs has been recorded. Symptoms of hyperthyroidism with enlargement of the thyroid gland due to increased blood-supply (resulting from thyroid arteries assisting in a collateral circulation) have also been met with.

Intermittent claudication

Hyperthyroidism

Signs

Examination of the chest may reveal the presence of tortuous pulsating vessels under the skin of the thorax; these are mainly branches of the subclavian and axillary arteries which are forming collateral anastomoses with the aortic intercostal and epigastric arteries. The abdominal aorta, the iliac, and the femoral arteries may be devoid of pulsation or pulsate but feebly. In any event there will be a great difference between the sphygmomanometric readings obtained in the arms and legs; the systolic pressure in the brachial artery may be in the neighbourhood of 200 mm. Hg, whereas that in the femoral may be less than half that figure. A pulse tracing of the femoral artery is small and plateau-shaped. It may also be possible to demonstrate a difference in temperature between the upper and lower extremities. The heart is commonly enlarged and murmurs due to the coexistence of valvular disease in some cases

Differences in sphygmomanometric readings in arms and legs may be audible. A long systolic murmur is usually heard towards the base of the heart conducted widely over the precordium and in the interscapular region posteriorly. Sometimes the murmur is also audible along the course of the anastomotic vessels. A radiogram of the chest shows a diminution in the size or absence of the aortic knuckle and in some cases the ascending transverse portions of the aorta are enlarged; a characteristic notching of the ribs due to pressure by the enlarged intercostal arteries is another feature of diagnostic importance.

Incidence In 200 cases collected by Hamilton and Abbott in 1928 the average age at death was 32 years, with extremes of 3 and 92. The chief causes of death are congestive cardiac failure, rupture of the aorta above the level of the coarctation, apoplexy due to cerebral haemorrhage, and the supervention of infective endocarditis, the area of coarctation being frequently involved.

Treatment Beyond protecting the patient from physical strain and infection, little can be done.

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ARTHRITIS

ACUTE ARTHRITIS

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RHEUMATOID ARTHRITIS

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ARTHRITIS IN CHILDREN, OR STILL'S DISEASE

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BONE DISEASES
CLIMATE IN THE TREATMENT OF DISEASE
EPIPHYSES: DISEASES AND INJURIES
GOUT
HYDROTHERAPY
JOINTS: DISEASES AND DISORDERS
RHEUMATIC INFECTION, ACUTE

I.—ACUTE ARTHRITIS

1.–ACUTE INFECTIVE ARTHRITIS

94.] Three acute infections are particularly susceptible to complications in the form of arthritis: (1) gonococcal, (2) pneumococcal, and (3) meningococcal. Apart from these almost all of the acute specific fevers may be complicated by arthritis. The arthritis may be either (1) non-suppurative, (2) suppurative, or (3) one of the manifestations of serum sickness.

(1)—Non-Suppurative

Association with scarlatina

Non-suppurative arthritis is usually mild and transient, and may be little more than a fleeting arthralgia. It is particularly frequent in scarlatina in adults, occurring towards the end of the first week. In children, however, a more severe form may occur, usually in the second or third week, which is indistinguishable from acute rheumatism, being frequently associated with carditis. There is, in fact, good reason to believe that this is actually acute rheumatism, which follows scarlatina just as it may follow any other haemolytic streptococcal throat infection, and as such it should be treated.

With typhoid

Typhoid fever may be complicated by an arthritis, particularly of the hip, which may result in spontaneous dislocation from the stretching of the capsule; this most often occurs in children. Very occasionally a fleeting arthritis may be found in other specific fevers.

(2)—Suppurative

With pyaemia

Suppurative arthritis may occur in acute infections when pyaemia supervenes on the original infection; for example in septic scarlet fever with necrosis in the throat and suppuration in the cervical lymphatic glands. The usual organisms are the streptococci or staphylococci, and this form of arthritis may be found in any pyaemic condition, particularly staphylococcal septicaemia. The affected joint is painful, swollen, and slightly flexed, and the overlying skin is red and oedematous. Aspiration reveals a purulent effusion in which the causal organisms may be found. Very rarely a joint may be involved in pyaemia and yet subside without actual suppuration. The treatment of suppurative arthritis is incision and drainage, care being taken to keep the joint in the position in which it will be most useful should ankylosis follow.

(3)—Serum Sickness

The arthritis of serum sickness occurs about ten days after the administration of a foreign serum. It involves several joints and is associated with the more usual urticarial manifestations of the condition. The arthritis is usually of short duration and is followed by complete recovery of the joint. There is evidence that arthritis may be prevented if the injection of serum is followed by the administration of salicylates, although the skin manifestations of serum sickness still appear (see Vol. I, p. 333).

2.—GONOCOCCAL ARTHRITIS

(1)—Aetiology

Incidence

95.] Arthritis occurs as a comparatively rare complication of gonorrhoea, the incidence varying from 1 to 4 per cent of all cases. Despite the relative infrequency of this complication, gonorrhoea is considered by some authorities as an important factor in the causation of subacute and chronic arthritis.

There are three views as to the pathogenesis of this form of arthritis: (1) that the arthritis is due to a metastatic lodgement of organisms in the joint tissues, (2) that the inflammation of the joint is due to toxins elaborated by the organisms in the local lesion, and (3) that the patient becomes hypersensitive to the gonococcus, and that the joint lesion is the manifestation of an allergic response to the local infection.

Gonococci in joint

The first hypothesis suggests the most probable mechanism by which the arthritis is produced; it receives strong support from the discovery of gonococci in the joint fluid and synovial membrane, although the fluid aspirated from acutely inflamed joints is often sterile. It is therefore possible that the clinical and pathological variations in the severity and type of arthritis complicating gonorrhoea are due not so much to variations in the virulence of the organisms and the resistance of the patient as to different mechanisms. Gonococcal arthritis may occur at any age although it is commonest between the ages of twenty and forty when gonococcal infections are most usual. Males are more frequently affected than females, although it must be remembered that 'puerperal arthritis' is frequently gonococcal in origin. The arthritis may occur at any stage of the local disease and is most frequently associated with an acute urethritis, usually in the second or third week of the infection; but it may start when the acute stage has subsided, and the patient has only a chronic discharge, or its onset may more rarely be deferred until all evidence of a local infection has disappeared. While arthritis is most commonly seen as a complication of genito-urinary infection it may be met with in extragenital infections such as ophthalmia neonatorum. There is some evidence that previous attacks of a non-gonococcal arthritis dispose to the occurrence of joint complications, and patients developing arthritis with one attack of gonorrhoea are very likely to do so again if further re-infection occurs. It has been claimed that injury to the joint may be a predisposing factor in determining the onset of arthritis, but recent studies have provided little evidence to support this view. Difficulty in the differential diagnosis between gonococcal arthritis and acute rheumatism may be caused by the fact that in both instances there may be a history of a recent acute infection of the upper respiratory tract.

(2)—Morbid Anatomy

Simple cases The morbid changes found in the joint vary considerably according to the severity of the attack. In the simplest type there is an infiltration of the synovial connective tissue with polymorphonuclear leucocytes, lymphocytes, and plasma cells without any destruction of the synovial membrane or effusion into the joint. This may progress to involvement of the synovial membrane with a serous or sero-fibrinous effusion which may or may not contain gonococci, or again the effusion may be frankly purulent. *Severe cases* In severe cases with effusion there is involvement of the synovial membrane with destruction of the superficial cells leaving an area of infected granulation tissue. Following this, destruction of cartilage and bone may occur. One of the striking features of gonococcal arthritis is the rapidity with which these severe changes may develop.

Healing may take place with complete functional restitution, but frequently extensive fibrous adhesions develop which may almost completely obliterate the joint space; in some cases exostoses and bony *After-effects* ankylosis occur. Deformity and limitation of the movement of the joint may also be occasioned by fibrosis and contractures of the periarticular tissues. These fibrous adhesions may develop after comparatively mild attacks but are very frequent after suppuration has occurred.

(3)—Clinical Picture

As a rule the onset of arthritis is sudden; but it may be very insidious as in the cases of painful heel with exostosis of the os calcis, which may occur long after the original infection has subsided. In the majority of cases the arthritis is polyarticular at the onset although in some cases one joint—almost always one of the large joints—may be involved alone. The joint symptoms, like the morbid changes, vary considerably, and only a simple arthralgia may be present without any changes in the external appearances of the joint which in a few days becomes normal without any sequelae. The usual picture is a sudden onset in the second week of local infection with red, swollen, painful joints into which there is some effusion. The latter varies in amount and it may be possible to aspirate 5 c.c. or as much as 150 c.c. In more severe cases the effusion is purulent and the infection may involve the periarticular tissue, producing oedema around the joint. There is usually fever at the onset which may be septic, irregular, or slight, but fever may be entirely absent. The fever usually subsides in a few days often leaving the joint condition little changed. The joint most commonly affected is the knee-joint, which is involved in the majority of cases, and the next in order of frequency are ankles, hips, and wrists. The joints of the lower extremities are more usually affected than those of the upper, but the disease not uncommonly involves the temporo-mandibular and sterno-clavicular joints in marked distinction from rheumatic fever. In addition to the actual arthritis, teno-synovitis may occur, frequently with suppuration.

Course

The course of gonococcal arthritis varies greatly. The acute symptoms usually subside within one or two weeks, but the infection in one or two joints—usually the larger—may go on to a subacute or chronic stage which takes six to twelve months to heal. With the milder types complete functional restitution of the joint is the rule, but permanent deformities with loss of movement and fibrous or bony ankylosis may result. Such severe sequelae are particularly common after a purulent arthritis, but even these cases may recover completely.

(4)—Prognosis

Complications

There is no reliable index as to the degree of permanent disability that will result, but evidence of bony involvement as shown by X-rays is almost always followed by permanent disability. The occurrence of other gonococcal complications, such as irido-cyclitis, septicaemia, or endocarditis, make the prognosis much worse and death may occur from a spreading gonococcal infection, although even cases of gonococcal endocarditis sometimes recover. With efficient treatment about 70 per cent of all cases make a complete recovery from the arthritis.

(5)—Diagnosis

A diagnosis of gonococcal arthritis may be made in the presence of: (1) a history of recent or previous gonococcal infection; (2) a local gonococcal infection as proved by symptoms, signs, or bacteriology; and (3) gonococci within the joint. The occurrence of other metastatic gonococcal lesions, such as conjunctivitis and iritis, teno-synovitis, and perichondritis of the arytenoid cartilage with pain on swallowing, may be of assistance in the diagnosis.

Pathological investigations

Accessory methods of diagnosis are provided by various pathological investigations. The gonococcal complement-fixation reaction is positive in either the blood or joint fluid in about 80 per cent of cases. There is usually a polymorphonuclear leucocytosis which may reach 20,000, but the white cell count is occasionally within normal limits; the sedimentation rate of the red blood-cells is raised. It has been claimed that small areas of decalcification just under the joint surface of the bone as shown by X-rays are diagnostic of gonococcal infection, but this change may occur in other forms of arthritis. Finally, in doubtful cases a provocative dose of gonococcal vaccine may be given subcutaneously; this produces an exacerbation of the joint symptoms.

Differential diagnosis

The differential diagnosis from acute rheumatic fever may be difficult, but the involvement of such joints as the temporo-mandibular and sterno-clavicular is in favour of gonococcal arthritis. But in acute rheumatism the fleeting involvement of different joints with complete recovery of the first joint affected is unlike the course of gonococcal arthritis, in which, although successive joints may be involved, those first affected do not clear up completely.

(6)—Treatment

The treatment of gonococcal arthritis may be considered under three headings: (1) treatment directed to the primary focus, (2) general treatment to raise the general resistance of the patient, and (3) local treatment to the joint itself.

Treatment of primary focus

The primary focus in the genito-urinary tract or elsewhere must be treated rigorously as described under the treatment of gonorrhoea. Surgical drainage may be required if any closed infection exists, such as a Bartholin's abscess, and Stellwagen has shown that in many cases of gonococcal arthritis there is an infection of the seminal vesicles. He claims that the treatment of this by the injection of 3 c.c. of Pregl's solution—the sodium salt of hydriodic acid and iodic acid with metallic iodine (0·04 per cent)—via the rectal mucosa is of great value.

General treatment

With regard to the general treatment of the patient, salicylates are of little value, and large doses of iodide—potassium iodide, 10 to 20 grains, three times a day—have been recommended, but are of doubtful value. In attempts to increase the patient's resistance vaccines and antisera have been tried. Some authorities consider that treatment with mixed gonococcal vaccines, in doses starting with 5,000,000 and increasing by 5,000,000 every three to eight days subcutaneously, is of great help. It is, however, generally considered that the effect of the vaccine is not specific, and that equally good results follow the injection of T.A.B. vaccine or even boiled milk. The gonococcal vaccine has the disadvantage that it frequently produces severe and unpleasant toxic reactions.

Artificial fever

Recently, Kendell, Webb and Simpson have reported excellent results from the treatment of gonococcal arthritis by artificial fever.

Local treatment to joint

Next to treatment of the primary infection, local treatment to the joint is of the greatest importance. In the acute stage the joint should be completely immobilized; but as soon as the acute stage has passed, gentle passive movement should be started to prevent the formation of adhesions. If there is much effusion it should be aspirated, and this procedure may have to be repeated. Should the fluid be purulent and recur after aspiration the joint may have to be opened and drained surgically. Pain may be relieved and resolution hastened by heat in the form of diathermy or radiant heat. Bier's passive hyperaemia is also of value in hastening recovery of the joint.

3.–PNEUMOCOCCAL ARTHRITIS

(1)—Aetiology and Pathology

96.] Pneumococcal arthritis is a rare complication of lobar pneumonia, occurring in less than one per cent of cases. It may complicate other pneumococcal infections; and about 25 per cent of cases of pneumococcal arthritis occur apart from any lung lesion. Weichselbaum in describing the pneumococcus in 1883 pointed out that it must be remembered that this organism 'can cause not only pneumonia but also various other diseases, either at the same time as pneumonia or entirely independent of it'. In children pneumococcal arthritis occurs more frequently than in adults, and is also more often found unassociated with pneumonia. It may occur as a complication of pneumonia at any stage of the disease, but it is usually metapneumonic. One or more joints may be involved, and as a rule the joint exudate rapidly becomes purulent although it may occasionally remain serous. The pneumococci may be found in the joint fluid.

(2)—Clinical Picture and Course

Differential diagnosis

Pneumococcal arthritis usually affects the larger joints and is often monarticular, the knee being the commonest joint affected. There is fever with a raised pulse-rate, and locally the joint is swollen, tender and slightly flexed. Diagnosis may have to be made from streptococcal arthritis complicating streptococcal septicaemia, or pyaemia; or from a staphylococcal arthritis. The latter is usually due to infection from metaphysial bone infection and is particularly common in children. In these two types constitutional symptoms are severe and well marked, and the skin over the joint is red, whereas in pneumococcal arthritis, although constitutional symptoms may be quite definite, they are usually mild, and there is, as a rule, little local redness over the joint which is in some cases strikingly pale. The final proof of the pneumococcal origin of arthritis is provided by aspiration and bacteriological examination of the fluid.

(3)—Prognosis and Treatment

As pneumococcal arthritis must be due to bacteriaemia—and over 50 per cent of the patients die from other pneumococcal infections, such as meningitis—the prognosis is always grave. The prognosis is better if the effusion is found to consist of thick pus than if it is thin and watery; it is also better in children than in adults. Fortunately there is rarely any extensive destruction of cartilage, and if recovery occurs there is likely to be little limitation of movement in the joint. The treatment consists, if possible, of complete aspiration of the effusion, and, if there is any recurrence, of surgical drainage. Anti-pneumococcus serum has been introduced too recently to justify conclusions of its value in pneumococcal arthritis, but it may certainly be tried.

Treatment

4.–MENINGOCOCCAL ARTHRITIS

First type

97.] Arthritis of three types may be met with in the course of a meningococcal infection. First, there may be a fleeting arthralgia involving many joints without any effusion and of short duration during the septicaemic stage of the disease. This type of arthritis occurs at the same time as the purpuric rash and is probably due to minute haemorrhages in and around the joint. It is particularly prominent in those cases of meningococcal septicaemia in which meningitis occurs, if at all, after days or weeks of illness, and in such cases it may raise the possible diagnosis of acute rheumatism or subacute bacterial endocarditis. The diagnosis is finally made by the discovery of the meningococci by blood-culture, or by the development of meningitis.

Second type

Secondly, there may be an acute monarticular arthritis occurring in the stage of meningitis. This type affects the knee, wrist, ankle, or elbow, and produces marked pain and swelling with slight redness of the overlying skin. The effusion is usually purulent and contains the organisms. The incidence of the complications is greater in adults than in children, and in different epidemics it occurs in from 1 per cent to 30 per cent of the cases. The treatment consists of repeated aspirations. As a rule complete resolution takes place with no permanent disability, and the complication of arthritis does not materially affect the prognosis of the original infection.

Third type

Thirdly, arthritis may complicate convalescence as one of the manifestations of serum sickness (see p. 69). This type is always polyarticular and associated with urticaria. It subsides rapidly and leaves no sequelae.

II.—RHEUMATOID ARTHRITIS

(*Synonyms:* Primary progressive polyarthritis; atrophic arthritis;
infective arthritis; infective polyarthritis)

1.–DEFINITION

98.] The name rheumatoid arthritis should no longer be used to include numerous forms of articular disease, but should be reserved for a definite group of cases clinically identical with those termed atrophic arthritis in America, and infective polyarthritis in France and Germany. It should be regarded as a generalized disease, the chief effects of which fall on the joints, rather than as a primary affection of the joints. The disease is most prevalent in temperate climates, being extremely common in England and Ireland. It attacks females more often than males in the ratio of about 4 to 1, young women probably suffering most frequently and severely. It mainly occurs during the child-bearing period; after the menopause its onset becomes progressively rarer.

Sex incidence

2.–AETIOLOGY

In the presence of rheumatoid arthritis a focus of bacterial infection is generally assumed to be present; but in a considerable number of cases this cannot be discovered, and some authorities consider that these cases are metabolic rather than infective in origin, a raised blood uric acid and cholesterol often giving some support to this view. Endocrine disturbances have also been thought to play an aetiological part. In the infective cases any of the following sources of sepsis may be responsible.

Prostate and Seminal Vesicles

Among the cases regarded as infective an important place must be given to those attributed to gonococcal infections. In the absence of a definite history of urethral discharge, a thorough massage of the prostate and seminal vesicles with a finger placed in the rectum may provide evidence; the 'bead' which appears at the urethral meatus should be carefully collected and examined, if need be, by a bacteriological culture. The gonococcus will not often be found in chronic cases, but the presence of secondary organisms in what should be a sterile fluid is highly suggestive; and aggravation of the clinical condition after prostatic massage transforms suspicion into probability.

Teeth

These are always deservedly suspect in rheumatoid arthritis. They should, however, not be removed simply on suspicion. A clinical examination of the teeth and gums should be carried out by a competent person, who should if possible be in a position also to X-ray the roots for hidden areas of absorption or sepsis; and the results of the clinical and X-ray examination should then be considered in conjunction. Far too many teeth are still condemned as the result of X-ray examination alone. When removal of teeth has been decided on, not more than two should be extracted at a time and if possible the patient should stay in bed for twelve hours afterwards; simple solution of iodine B.P. in doses of 5 to 10 minims (well diluted with water or milk) during the whole period when extractions are being carried out will often minimize any resulting reaction.

Tonsils

These probably are as often foci of infection as the teeth. It would, however, be illogical consistently to condemn tonsils merely on account of their size, unless this is such that there is a possibility of respiratory obstruction. The association of a cyanotic flush extending on to the faucial pillars, enlargement of the tonsillar glands, more especially in young persons, and, most important of all, a clinical history of recurrent sore throat should strongly suggest infection even in the absence of any enlargement of the tonsils themselves. The statement that the tonsils have already been removed should be received with reserve, since the benefits that follow the removal of tonsils which had previously been 'removed' in childhood are often striking. After incomplete removal fibrous tissue forms over the damaged surface, and effectively prevents drainage of toxic substances, except into the lymphatic or blood-stream. If possible, therefore, tonsils should always be dissected out rather than guillotined, and if tonsillar remnants are present they should in appropriate cases be removed.

Gall-Bladder and Appendix

These are foci of infection more often than is generally recognized.

Maxillary and Frontal Sinuses

These frequently show evidence of infection if carefully examined with the aid of transillumination, and possibly X-rays. Often, however, a chronically infected, thickened mucous membrane, rather than the presence of free pus which drains at intervals into the nasal passages, is of greater aetiological importance. In such cases nasal drainage yields no result, and washings may be sterile. Cultivation of a piece of the thickened lining, however, will generally show infection in the deeper layers.

Colonic Infection

The colon being the main drainage system of the body, one would naturally expect its contents to be infected; too much attention should therefore not be paid to casual bacteriological reports on the faeces. In some cases, however, there can be no doubt that improvement may be obtained by altering the intestinal flora by the ingestion of carbohydrates, or of cultures of *B. acidophilus* or *B. bulgaricus*. It is also known that arthritis may be the sequel of certain colonic infections such as enteric fever or bacillary dysentery. If a pathogenic bowel infection is suspected, samples for culture should be taken by means of colonic lavage rather than from the faeces themselves, unless these are naturally loose. No purgative should be given previously, although a preparatory lavage may well be carried out on the previous day to remove debris. When organisms common to the gums and teeth predominate, the colon must be considered to be a secondary focus of infection. Indeed it is doubtful if *B. coli* can ever become a causal organism in arthritis, the organisms commonly considered to be pathogenic in this respect being mostly of the streptococcus group.

Miscellaneous Infections

Other septic areas have been frequently described, but each case must be considered on its merits. Conditions such as otitis media are only of occasional importance. Whether the infective element in rheumatoid arthritis may not ultimately prove to be an attenuated form of the tubercle bacillus, circulating in the blood at certain times only and localizing largely at the joints, is a question still undecided.

3.–CLINICAL PICTURE

Pre-arthritic period

A pre-arthritic period is recognized by many authorities. It resembles that of tuberculosis, and presents the signs and symptoms of a mild chronic infection with some endocrine abnormality. The rheumatoid arthritic is usually conscious of abnormal fatigue on moderate worry or exertion, and an examination of the blood will reveal secondary anaemia. A history of irregular menstruation and slight thyroid enlargement is common. Vague muscular pains are troublesome, and the extremities, although cold, are generally moist.

Arthritic period

The arthritic period frequently begins with periarticular swelling of the two middle fingers of each hand. This is not necessarily permanent and may disappear to be followed shortly by similar swelling, it may be, of the wrists or toes. The characteristic feature throughout is the bilateral and symmetrical distribution of the joint-changes. These will rapidly be followed by wasting, chiefly apparent in the small muscles of the hands and of the skin covering the affected joints. Tachycardia, pigmentation, and a persistent low-grade pyrexia may also occur at this stage. The general condition of the patient progressively deteriorates, fatigue and malaise becoming more pronounced, and the body-weight will generally fall by about a stone. The involvement of the joints proceeds centripetally; the fingers, the metacarpo-phalangeal joints, and then the wrists become involved, and ultimately the larger joints are also affected. Sometimes even the spine is attacked.

4.–PATHOLOGY AND PROGNOSIS

Morbid changes

The pathological course which arthritis pursues inside the joint cavities varies. The process may become arrested at any stage, although it is rare for the patient to survive without permanent joint-lesions. The process is one of active inflammation starting in the synovial tissues and gradually spreading both over and under the articular cartilages. Vascularization and absorption of the cartilage and of the adjoining bony areas follows, and the destruction of the joint surfaces will appear in an X-ray picture as typical 'rat-bitten' areas. The other most typical appearance on the X-ray plate is the marked decalcification of all the bones, which appears very early in the disease and will remain until the various morbid processes are no longer active. The vascular proliferation and the destruction of the articular cartilages which separate the bones forming the joint, rapidly lead to fibrous adhesions between the bones, and in some cases this may ultimately result in true bony ankylosis. While this process is active within the joint, the muscles which surround and move it will waste progressively, and the tendency to contracture will become manifest.

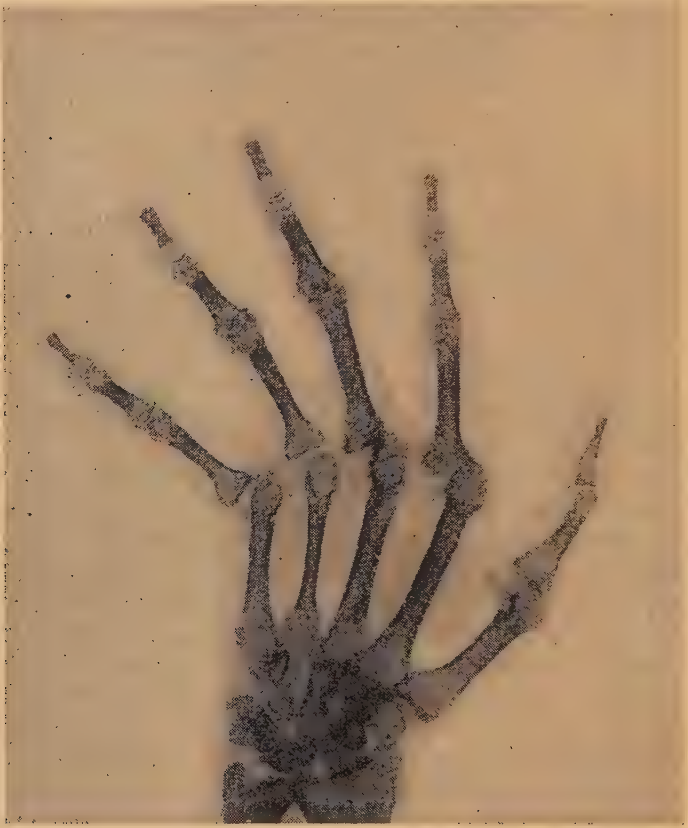

FIG. 22.—Quiescent rheumatoid arthritis of 15 years' duration in a female of 38
[From *Radiological Atlas of Chronic Rheumatic Arthritis* (*the Hand*),
by S. Gilbert Scott]

End-results

The ultimate condition of the patient if the process is unchecked will be one of crippledom, varying according to the particular joint localization. The hands show wasting, the fingers ulnar deviation and loss of grip, and may in addition become subluxated. The wrists generally become ankylosed, usually in a slightly flexed position. The elbow can seldom be fully extended, and the movement at the shoulders and ankles may be much limited. The knees will generally be flexed to a variable extent, and in chronic cases the tibia may be dislocated backwards on the femur—a rather hopeless state of affairs from the therapeutic standpoint. The hips, if affected, will also be drawn into flexion, and the wasting of the muscular system renders movement of any affected joint difficult, even if it be possible. The spine is rarely involved alone in this catholic distribution of joint disability.

5.–DIAGNOSIS

In the early or pre-arthritic stage diagnosis may be most difficult unless the possibility of an insidious onset with pyrexia be borne in mind. The chief alternative diagnoses are rheumatic fever and tuberculosis, the lack of response to sodium salicylate pointing to the latter. In tropical climates arthritis has been described as a sequel of bacillary dysentery, but it has been recently suggested that the condition in these cases is merely serum arthritis consequent on the treatment of the dysenteric condition. Byam, however, observed such cases in the days before serum was used.

Differential diagnosis

Enteric fever may in some instances be followed by an arthritis of the rheumatoid type. This must, however, be differentiated from the more common periostitis which may at first simulate an arthritic condition. Dengue is said rarely to result in arthritis; when it does, the arthritis is generally confined to one or two of the larger joints and is unlikely to be confused with the rheumatoid type.

6.–TREATMENT

(1)—General

In rheumatoid arthritis, as in other cachectic conditions, the risk of over-treatment is as real as that of under-treatment. Measures which exhaust the patient seldom produce a satisfactory end-result whatever their theoretical value. When possible, the intelligent co-operation of the patient is essential, since the disease is chronic and at times progresses rapidly. As the disease is not confined to the joints alone treatment must be both general and local.

General treatment

General measures should include attempts to raise the weight of the patient to the expected normal, if necessary by reinforcing dietetic methods with insulin (see p. 81). It would also seem reasonable to adopt treatment on the same lines as in chronic tuberculosis, by a maximum of rest, fresh air and light. In addition to vaccines, when these are indicated, physical measures aiming at mild stimulation of the skin, and thus raising the resistance to the disease, should also find a place in the general treatment. These measures will generally include ultra-violet light with or without very light skin massage (effleurage). Medicinal treatment is principally analgesic.

Local treatment

Local measures include all methods of reducing pain and aiding the resumption of free movement in the affected joints. Such measures should be considered strictly apart from those mentioned above, since, although necessary, they have no ultimate curative value for the disease as a whole.

The place and value of various methods of treatment, both internal and external, must in every case be considered in the light of the foregoing remarks and in conjunction with the physique and needs of each particular patient. 'Rule of thumb' methods are of no avail for the management of these difficult cases.

(2)—Medicinal

Injection of Gold Salts

The most promising drugs are gold salts (crisalbine, sanocrysin), injected either intramuscularly or intravenously at intervals of five to eight days. Recent experience, however, has shown that some patients are or become intolerant of these substances and that their use in such cases is by no means without danger; stomatitis, jaundice, diarrhoea, nephritis, and rectal spasm have been reported, and exfoliative dermatitis with intense itching is perhaps the most common. Intolerance cannot be detected beforehand, although the presence of albuminuria, high blood-pressure, hepatic insufficiency, or senile changes must weigh against the choice of gold-salt treatment. But among those tolerant to gold salts a certain proportion of cures may be expected, provided that the condition of the joints is not already so advanced that the resumption of movement is impossible even when the disease in the joints is no longer active. Improvement can seldom, however, be looked for under three to four months. Somewhat larger doses are recommended on the Continent than are considered advisable in Great Britain; the initial dose should not exceed 0·01 gram, and the urine should be tested a few hours later. If any sign of intolerance is manifest, however slight, it is wiser not to pursue this method of treatment. A second injection may contain 0·05 gram and subsequently the dosage may advance to 0·1 gram. Beyond this, however, it is unwise to go. The total amount of the gold salt given in each course of injections must never exceed 1 gram. After this an interval of eight to twelve weeks elapses before the course is repeated. Second and third courses must be given only if the patient can be kept under strict observation.

Sequelae of gold therapy

Calcium Gluconate

Calcium gluconate

Calcium gluconate by intravenous injections (7½ to 15 grains in 5 to 10 c.c.) three or four times weekly seems in some cases to prove beneficial. It may conveniently be used between courses of gold-salt injections if the continuance of active treatment is considered desirable.

Cinchophen

Cinchophen

Derivatives of quinoline-carboxylic acid—e.g. cinchophen (phenylcinchoninic acid, atophan, phenoquin or agotan)—are sometimes of value, particularly in acute cases in young women. They should never be given for more than two days in any one week, and then only in moderate doses together with 30 to 60 grains of sodium bicarbonate. They are liver poisons and have caused fatal hepatic necrosis. If without effect after a fortnight they should be stopped.

Arsenic, ortho-iodoxybenzoic acid

Of the other numerous drugs recommended for the treatment of rheumatoid arthritis both arsenic and compounds of ortho-iodoxybenzoic acid have a considerable following in America.

Most proprietary preparations are merely analgesic and cannot be relied upon from a curative point of view. Many also contain phenylcinchoninic acid and so may even be dangerous.

Analgesics

Aspirin, calcium acetysalicylate

Of the analgesic group aspirin (acetylsalicylic acid) seems to be the most generally useful. Calcium acetylsalicylate has recently been recommended as superior because it is soluble in water and does not irritate the gastric mucosa. In many cases the action of an acetylsalicylate alone is not sufficient, and its effects may then be reinforced by some centrally acting drug of the phenazone group, such as amidopyrine (pyramidon) or novalgin; but the danger of agranulocytosis must be borne in mind. Occasionally recourse must be had to opium derivatives, when a prescription such as aspirin 7 grains, caffeine 5 grains, codeine phosphate $\frac{1}{6}$ grain—or aspirin 10 grains, Dover's powder 10 grains—will be found useful, especially if sleep at night is interfered with.

(3)—Dietetic

Diet must be adapted to each particular patient. No routine diet will be entirely successful. The average sufferer, however, is considerably under normal weight, and the first task is to restore the normal weight and increase resistance. Meat need not be omitted from the dietary; the suggestion that it should be doubtless arose from the necessity for this measure in gout, which was formerly confused with rheumatoid arthritis. A nourishing mixed diet, rich in all vitamins, should be prescribed, and carbohydrates may be restricted. Small amounts of cod-liver oil should also be recommended after meals, and an additional quantity of milk daily, between or with the meals, will not only tend to increase the body-weight, but add to the depleted reserves of calcium in the blood-stream. When these measures fail to increase the weight, the carbohydrate intake should be increased by the addition of glucose at the midday meal after an injection of 15 units of insulin twenty to thirty minutes beforehand. This may be continued for five or six weeks; the average increase in weight generally varies from 2 to 4 pounds a week, after a latent period of ten to twenty-one days.

Fruit

Unless known to disagree with the patient, fruit should be recommended; there is no justification for the exclusion of citrous fruits on account of their reputed acidity, but it may be wiser to exclude strawberries and tomatoes.

Alcohol

Alcohol in the form of wine or beer should be excluded, but a depressed and wasted patient with toxic fatigue may sometimes be allowed a small dose of whisky or gin with the evening meal.

(4)—Vaccine Therapy

Indications

Vaccines succeed in a minority only of cases. Small doses may be tried in cases in which a definite focus of infection, which may be held to be the responsible cause, has been found and drained. But as a rule a vaccine should not be given unless there is some sign that the patient's resistance is already improving and may profit by further stimulation. Except in the hands of bacteriological experts there seems little difference in the effects produced by stock and by autogenous vaccines. The common mistake in their administration is a desire to 'work up' the dose; there is no evidence of virtue in high dosage as such. When good results follow small doses of vaccine it is generally advisable to maintain them so long as the benefits continue. When progress stops the doses may be slightly increased. It must, however, be remembered that every therapeutic measure which, if rightly used, is potent for good, may be equally potent for harm if wrongly used. There is no doubt that disastrous 'flare-ups' have sometimes been caused by unwise vaccine therapy.

(5)—Protein-Shock Therapy

Non-specific protein therapy is unjustifiable in the presence of active rheumatoid arthritis. Occasionally a period of benefit may occur, but this is in most cases succeeded by a more permanent phase of recurrence. When the disease is no longer active and the joints are thought to be capable of some degree of restoration of function, it may be tried, and is sometimes helpful. T.A.B. vaccine or yatren-casein are the most convenient methods of applying it.

(6)—Physical Methods

These methods are necessary at some stage in almost all cases of chronic arthritis of whatever form. Physical therapy has been somewhat neglected. Roughly speaking it consists in the application of heat, movement, or stimulation of the skin, by any of many methods. In rheumatoid arthritis the use of baths and other tiring general methods is usually contra-indicated on account of the frail physique of the patient; the two most valuable methods are the application of ultra-violet light and skin massage (effleurage). For the local treatment of the affected joints, many methods are possible; heat (which may be applied either moist or dry) is sedative; it decreases muscular spasm and increases the local circulation.

Heat

Moist heat may be applied locally by means of poultices, kaolin packs, antiphlogistine (kaolin poultice B.P.C.), mud, melted paraffin wax, and local arm-and-leg baths containing water or oil. When more elaborate apparatus is available the local steam cabinet (Berthollet) is useful.

Dry heat may be applied from salt packs, sand, portable radiant heat or infra-red lamps, gas stoves or an electric heating pad such as can be plugged into an ordinary circuit. More elaborate methods of electrical treatment, such as diathermy, infra-red tunnels, or short-wave therapy have a similar objective, but require skilled handling, preferably in an institution.

Movement

Movement is used either actively to rebuild wasted muscle, or passively to maintain or restore the function of a joint. Active movement is very necessary in the later stages when the virulence of the disease is spent, but the wasting remains. Active controlled movements, performed by the patient several times daily are the method of choice, but these may be reinforced by the surging faradic current from a Smart-Bristow coil. This will induce muscular contraction painlessly, but there is a danger that patients may tend to rely upon it and neglect to work out their own salvation.

Weight-bearing

Weight-bearing must be considered quite separately from movement, the former being undesirable until muscular balance and support have been restored by the latter. The necessary prescribing of exercises will not therefore be confused with the unsound advice to 'walk it off' which will doubtless be received by the patients from their friends. An arthritic joint must not bear weight until it is fit to do so.

Manipulation

Manipulative methods are the logical conclusion of assisted movement. When some mechanical obstruction, such as a capsular adhesion, interferes with full movement, manipulation may render fuller movement possible for the future. In some cases, in which the infection is no longer active, it may so increase the range of movement as to render life easier to patients who have to some extent been crippled. But the actual manipulation is not all sufficing, since when increased movement has been produced, it is equally important, and more difficult, to retain it. This end can be achieved by intensive after-treatment.

(7)—Colonic Therapy

This has been advocated as a panacea for this disease. It is nothing of the sort, whatever solution is used for the purpose, although it helps some patients in the later stages. Possibly the result is achieved by the mechanical removal of bacterial debris, or it may possibly have some more obscure action as yet not understood. It does not apparently much matter what solution is used, and common salt 1 drachm, sodium bicarbonate 1 drachm, and water to one pint form an excellent isotonic mixture. If the faeces are offensive a few grains of potassium permanganate may be added. This procedure should not ordinarily be employed more than once a week, as it tends, by taking the place of natural evacuation, to render the patient somewhat dependent upon it. It may in some cases be advisable to endeavour to supersede the natural bacterial inhabitants of the lower bowel by *B. acidophilus* or *B. bulgaricus*, in which case a fresh culture of one of these may, on several occasions, after a routine lavage, be slowly run into the colon and retained. To enable these organisms to gain a firm foothold, however, the ingestion of large quantities of lactose and dextrose by mouth is usually required over a considerable period.

Alteration of bowel flora

(8)—Orthopaedic Measures

Orthopaedic co-operation is essential in long-standing cases and should be employed more frequently than at present. Open operation is seldom necessary during the active period, since the patients are not good subjects for this treatment. *Splints* The question whether or not to apply splints is important in early cases, and should always be faced by the physician in charge of the case, in order to avoid gross deformity. The wrists generally tend to drop and the power of gripping is thus impaired; this can be counteracted by the use of a 'cock-up' splint worn at night, and faradic treatment of the weakened extensor muscles by day. An affected knee showing signs of flexing permanently should be put into a bivalved plaster splint, or on to a back splint of the McIntyre type, which is fitted with a screw extension adjustment. If this is not available a weight of 5 to 7 pounds attached to a cord from the patient's ankle may be hung over the end rail of the bed during sleeping hours. The foot of the bed in these cases must be raised slightly for the purpose of counter-extension.

(9)—Additional Methods

Blood transfusion In severe or resistant cases these may include the administration of 500 c.c. of normal blood to the patient on two or more occasions at an interval of a week. This should be followed by intensive physical treatment which the patient will then tolerate more readily. The patient should then receive the insulin and high carbohydrate diet already referred to. The results of such treatment are never dramatic, but an otherwise progressive case will often gradually become inactive. For assessing activity in rheumatoid arthritis the blood sedimentation rate may supply useful supplementary information, but it is not of any help in diagnosis.

A further method of treatment, well spoken of in America, is sympathetic ganglionectomy. The operation is severe and is seldom done in this country, for it is believed to give only temporary benefit.

Deep X-ray treatment has sometimes been advocated but there is little either on theoretical or practical grounds in its favour. *Diathermy* The passage of a mild diathermy current through the pelvis has met with some success. This is done by means of a vaginal or cervical electrode and a pad placed over the surface marking of the ovaries. It is believed that the ovarian secretion is increased with beneficial results in early cases of the disease.

Spa treatment Spa treatment should include the most desirable combination of the foregoing methods in the best natural environment. Mental and physical relaxation is more easily attained in these surroundings, and the patient's complete energies can be concentrated on the treatment. The natural waters of any particular spa must be considered in relation to the patient's needs, but it is possibly even more important to arrange that the entire régime shall be in expert hands. The dangers of over-treatment are no less than those of under-treatment, and patients should not therefore aim at getting as much treatment as possible into the period of their stay; this is a common and fatal mistake. When choosing a spa suitable for rheumatoid arthritis care should be taken to avoid too bracing or too hilly a locality, and although, when resistance is returning, spa treatment is invaluable for those who can afford it, it is likely in the earlier stages while the disease is highly active to affect adversely the progress—bed rather than active physical measures being then indicated.

III.—MENOPAUSAL ARTHRITIS

1.—DEFINITION

99.] This term describes a type of arthritis which occurs in women within the five or six years preceding or following the cessation of menstruation. Any of the various forms of arthritis may begin during this period, although rheumatoid (atrophic) arthritis usually begins much earlier, and osteoarthritis (hypertrophic) somewhat later. In general, menopausal arthritis more closely resembles osteoarthritis, from which, if left untreated, it is almost indistinguishable in its later stages. The importance of recognizing this type is that with early and appropriate treatment it can be completely cured in the majority of cases, or at least arrested before it leads to crippling deformity.

2.—CLINICAL PICTURE

Onset

The onset is usually insidious, and at first it causes little inconvenience. Those affected have often enjoyed perfect health and accept the early aches and stiffness more or less philosophically as a sign of old age, though they are only in the neighbourhood of fifty. A tendency to put on weight and a little shortness of breath occurring at the same time may be regarded in the same manner, and many of these patients do not seek medical advice until there is a sudden exacerbation of pain in the knees or hands—the joints most commonly affected.

The appearance of painful swelling of one or more—usually several—of the terminal finger-joints may impel the patient to seek medical advice in the fear that rheumatoid arthritis is beginning; if, however, on examination the doctor can satisfy himself that this disease is not present he can lift a load from the patient's mind, which in many cases is little less than that caused by the fear of cancer. It is therefore important to distinguish, if possible, menopausal arthritis from other forms of arthritis during a first examination.

In the first place, in the absence of any other ailment, these patients do not look toxic, or anaemic, or otherwise ill. They are usually fairly well nourished. There is not as a rule a history of tonsillitis, influenza, or other infection preceding the onset of the discomfort in the joints. The knees are almost invariably affected and the patient will have experienced discomfort in rising from low chairs, in standing for long periods, in walking long distances—particularly down hill—or in going downstairs.

Joint symptoms

In the early stages the joint symptoms and signs are exactly those of chronic synovitis. Palpation over the synovial membrane on the inner side of the knee will reveal thickening, and firm pressure with the finger tip will cause localized pain. Flexion and extension of the knee with the hand over the knee-cap will give a sensation of soft velvety crunching. There is seldom sufficient free fluid to cause riding of the patella but the knee-joint is enlarged as a whole. The joint is not hot and as a rule muscle-wasting above or below the joint is absent.

X-ray appearances

An X-ray examination at the early stage does not show any bony changes nor will it show the increased density of the surrounding tissues which accompanies the bone rarefaction seen in atrophic arthritis. Later on bony spicules appear and still later lipping and loose bodies develop, but by this time the bony changes are indistinguishable from those of ordinary hypertrophic arthritis, and this stage should not be reached if early treatment has been efficient.

Appearance of the hands

The appearance of the hands in menopausal arthritis is also characteristic. The wrists may be affected, but usually the joints picked out are the carpo-metacarpal joints of the thumbs and the terminal joints of the fingers. In the early stages and during the 'flare-ups' which occur from time to time these terminal joints are tender at the sides, and although there is no true fluctuation periarticular infiltration conveys a somewhat elastic feeling to the palpating fingers.

Heberden's nodes

This rubber-like swelling can be dispersed by physical treatment, as will be mentioned later; but once the bony thickenings of these joints —known as Heberden's nodes—have formed, a hard residual swelling will always be left, however successful treatment may have been in removing the pain and soft swelling. Not infrequently the terminal finger-joints become so red, shiny and painful that they are diagnosed as gouty, but in the absence of tophi and a history of typical gout in other joints this diagnosis should not be made unless confirmed by a blood examination.

Signs of thyroid deficiency

The other physical signs of menopausal arthritis are mainly those of thyroid deficiency, ranging from small localized patches of fibrositis to well-defined myxoedema. The fibrositis is usually localized in more or less circular areas unlike the widespread areas of panniculitis formed around the ribs in adiposis dolorosa. These areas may be mistaken for lipomas, but they are tender on pressure, and the edges are not so well defined as those of simple fatty tumours. One can usually be found centering over the seventh cervical vertebra, and the tenderness, when present, often extends outwards along each supraspinatus muscle towards the shoulders. Sometimes areas of fibrositis are seen as pads above the clavicles. In the legs they are commonly found on the inner sides of the knee-joints with separate swellings just below, over the inner sides of the upper ends of the tibiae, and occasionally on the outer side of the thigh just below the great trochanter. They may be seen on each side of the ankle and across the dorsum of the foot. The swelling here does not pit so readily as in ordinary oedema, but indentations can be made by firm pressure. Other signs of thyroid deficiency often present are brittle hair on the scalp, thinning or absence of the outer half of the eyebrows, and a dry harsh skin; but these signs are by no means always present.

3.–DIAGNOSIS

From rheumatoid arthritis

The most important diagnostic point is not to mistake these menopausal enlargements of the terminal interphalangeal joints for rheumatoid arthritis. In rheumatoid arthritis affecting the hands there is usually symmetrical spindle-shaped swelling of the proximal interphalangeal joints, with muscle wasting, especially of the interossei, and often trophic changes of the nails; the fingers are usually blue or very pale and cold, and the palms are often wet with clammy perspiration.

An X-ray examination in rheumatoid arthritis shows rarefaction and narrowing of the joint slits at a comparatively early stage. Between the typical rheumatoid hand and the typical hand of menopausal arthritis are those showing some of the characteristics of both types. These appearances may be caused by infective arthritis, but in this condition the joint involvement will be more widespread than in menopausal arthritis, and a careful search will reveal some source of focal infection. Evidence of such infection may be entirely lacking both in true rheumatoid and in uncomplicated menopausal arthritis.

4.–TREATMENT

The treatment of menopausal no less than of other forms of arthritis calls for a complete investigation of the patient. Any brief consideration will show that no single drug, vaccine, or other remedy could reasonably be expected to cure the various manifestations of what is essentially a systemic disorder, the inflammation of the joints being only one of the symptoms.

Infection, trauma, and endocrine deficiency are the main causative agents in arthritis, and of these infection certainly plays a less and trauma and endocrine deficiencies a greater part in menopausal than in atrophic arthritis. The fact that cases presenting such a well-defined clinical picture as these under discussion occur only in females, and almost exclusively in the decade of menopausal changes, is strong evidence that a general waning of endocrine activity is the most important causative factor.

Removal of septic foci

Neither the patient's appearance nor the blood-picture suggests infection. Focal infection may co-exist, but the menopausal syndrome is quite as likely to be the cause as are the localized infective processes. Obvious septic foci such as decayed teeth should be removed, but wholesale extractions may do harm by suddenly flooding the system with much toxic material from the resulting large raw area, and to avoid this infected teeth should be removed one or two at a time with a sufficient interval between extractions for the gums to heal. In any case dramatic curative effects should not be expected from the removal of either acute or chronic sources of infection in this type of arthritis.

Treatment of constipation

In middle life a pendulous abdomen with visceroptosis is often associated with defective action of the bowels. A glass of hot or cold water on wakening, a tablespoonful of liquid paraffin before breakfast, and if necessary a little cascara or senna in addition at bedtime are useful temporary correctives, but deep-breathing exercises and exercises to tone up the abdominal muscles should be performed regularly. These exercises can be done in the recumbent or sitting position without putting any additional strain on painful knees.

Diet

The diet also needs attention. Many of the patients have a lowered sugar tolerance, or at least a delayed rate of removal of sugar from the blood-stream, and it is now known that there is a close relation between the contents of the synovial fluid and the blood. In overweight patients a sharp reduction in the proportion of carbohydrates and a reduction in the total intake of food is usually beneficial. The patient should have a sufficiency of green vegetables, fresh fruit, butter, cream, and eggs. A little marmite or yeast will ensure a sufficiency of vitamin B, and phosphorus and calcium metabolism will be aided by the administration of vitamin D with if necessary a calcium salt—e.g. calcium gluconate with calciferol, ostelin, or calcydic. These measures will result in improved nutrition and hasten the removal of waste products.

Care of the feet, knees, and joints

Trauma plays a part in the onset of menopausal arthritis, if the wear and tear on the knee-joints which is so much increased by flat foot or valgus in heavy persons is regarded in this light. Instep supports and straight inner-sided shoes with the inner sides of the heels raised and prolonged forwards will alleviate these conditions. Corns either under the feet or on the dorsum of the toes may affect the gait to the disadvantage of the knees and should receive skilled attention. Kneeling should be avoided as much as possible, but it may comfort some patients if it is pointed out that devotional kneeling on a raised hassock with the body-weight partly supported by a chair or pew will do no harm. Kneeling on stone floors for scrubbing, or even gardening, is much more harmful, for both involve contact with cold, hard surfaces and a degree of flexion of the joints which may nip the synovial fringes. When the wrists are affected anything which puts a strain on the joints, such as wringing out wet cloths or turning stiff door-handles, should be avoided, as even one single effort of this sort may set up pain and effusion which may last for days.

Exercise

The medical adviser is usually asked about exercise. Stairs should be avoided as much as possible, but walking, on an even surface for preference, is the best form of outdoor exercise. The patient should not go so far from home that she is in pain or unduly fatigued on her return journey. No exercise is almost as bad as over-exercise and a middle course must be steered. Sitting with the heels under one's chair for long periods tends to encourage flexion deformity. The daily hot bath is helpful and while in the bath the patient should massage her own joints and move them through the widest range possible whilst they are still relaxed by the warmth and moisture.

During acute exacerbations great relief is given by rest and the application of kaolin poultice B.P. (antiphlogistine), or by painting with weak solution of iodine followed by linseed poulticing.

Aspirin

Drug treatment is of only secondary importance as compared with the foregoing general measures. Aspirin in doses of 10 grains night and morning may be given when there is much pain, and if it causes dyspepsia this can usually be avoided by taking it in a little milk. For patients who cannot tolerate ordinary aspirin even in milk, the so-called 'stabilized' calcium aspirin, which is soluble, may be tried. If aspirin causes perspiration, sodium salicylate and sodium bicarbonate (10 to 15 grains of each three times daily after meals) may be given for a week or ten days. I have noticed that some patients who are nauseated by this mixture dispensed in chloroform water can take it dispensed in plain water. Apart from its value in easing pain sodium salicylate has an antiseptic action on the gall-bladder, and this may account for the fact that it will often lessen the putrefactive odours of the stools, which may assume a light yellow colour during its administration. Massage of the swollen joints with methyl salicylate ointment B.P.C. or some of the rather more easily absorbed proprietary wintergreen ointments is helpful.

Iodine

Next in importance is iodine. Potassium iodide has long been used in all forms of chronic rheumatism; latterly the French tincture, or simple solution of iodine B.P., given in milk has been extensively used; and Oppenheimer's 'alphidine', a sodium compound of iodine of which one pulverette equals half a grain of iodine, may be given three times daily after meals. Although the majority of menopausal arthritics are of the sthenic type, some of them are anaemic and derive much benefit from a two or three weeks' course of iron and arsenic by mouth.

Thyroid

Thyroid is indicated when signs of myxoedema occur, and the indication is equally definite in the presence of a lowered basal metabolic rate, although in my experience this is not common. Even without definite hypothyroidism, provided there is no tremor or other sign of hyperthyroidism, small doses of thyroid—say $\frac{1}{4}$ and not more than $\frac{1}{2}$ a grain—may be given night and morning before meals, and this, with regulation of the diet, will probably aid in the desired weight-reduction. Thyroid, $\frac{1}{4}$ grain, taken with one alphidine pulverette night and morning makes a useful combination, but the pulse-rate should be taken at least once a week until the response has been noted, and a warning should be given that palpitation or shakiness of the hands is a definite indication for stopping both thyroid and iodine until a further examination has been made. In view of the probability that follicular hormone deficiency is at least partly responsible for arthritic as well as for other abnormalities appearing at the menopause, standardized oestrogenic hormone preparations (menformon, progynon, thelestrin) may be given, and in sufficient dosage—e.g. 1,000 to 10,000 international units (oestrone standard) by injection every other day—frequently produce considerable benefit. It is probably owing to stimulation of the ovaries that pelvic diathermy gives good results in some cases. Pelvic sepsis has not been discussed as, although its effect may be seen during the menopausal decade, it is associated with infective rather than menopausal arthritis.

Physical measures

Physical treatment is by no means the least important. Massage daily or on alternate days for two or three weeks will aid the removal of the localized patches of fibrositis as well as improve the condition of the joints. Paraffin-wax baths to the hands and wrists, or steam baths to the arms and legs, followed by massage, are particularly helpful, and Turkish baths, unless prohibited by the patient's general physical condition, may be taken once or twice a week with benefit. These measures all improve the capillary circulation which is defective in most cases of arthritis. As a result of this defect the tissues cannot take up the normal amount of oxygen, and a higher percentage of oxygen than normal is found in the returning venous blood. This affects adversely both muscle nutrition and the calcium metabolism of the bony structures.

Spa treatment

The ideal way of taking these physical treatments is for the patient to visit a spa. Three or four weeks of the spa régime, where the patient's whole time can be devoted to taking baths and waters uninterrupted by social or domestic duties, will probably bring about more improvement than a much longer period of home treatment. Of all forms of arthritis the menopausal form is the most amenable to spa treatment. The sulphur waters of Harrogate, Llandrindod, and Strathpeffer, and the radioactive waters of Bath and Buxton are quite as efficacious as those of any of the foreign spas in this condition. Detailed accounts of the spas of the British Isles and of the British Commonwealth overseas are given in 'The Official Handbook of the British Health Resorts Association'.

In conclusion, emphasis may again be laid on the fact that with early diagnosis and prompt and thorough treatment uncomplicated menopausal arthritis is curable. Inefficient treatment or delay in beginning treatment until irreparable damage has occurred in the joints will lead to an old age with the discomforts and disabilities common to other forms of arthritis.

IV.—OSTEOARTHRITIS

Synonyms.—Chronic arthritis of osteoarthritic or degenerative type (British National Committee); degenerative arthritis (Nichols and Richardson); hypertrophic arthritis (Goldthwait); osteoarthrosis; arthritis deformans (German); *arthrite déformante* (French).

1.–DEFINITION

100.] In a Hunterian lecture in 1922 the author ventured to define osteoarthritis as follows: 'Osteoarthritis does not constitute a disease *sui generis*, but rather the series of physiological or pathological changes in a joint when it is subjected to prolonged or oft-repeated injury, either mechanical or toxic, but of a moderate degree of intensity'.

It is possible that nutritional factors also play a part. This condition of the joints, with its combination of degeneration and proliferation, has afflicted not only mankind but the lower animals from remote periods in the Earth's history. The changes have been noted in the spinal column of a dinosaur of the triassic period, and many of the bones of ancient Egyptians show typical signs of osteoarthritis. In fact, in hieroglyphic writing the determinative of old age was the figure of a man crippled with arthritis.

2.–AETIOLOGY

(1)—Incidence, Distribution and Predisposing Causes

Osteoarthritic changes are apt to supervene in any joint the function of which has been altered by injury or disease, especially when the shape or alignment of the articular surfaces has been modified. The changes do not as a rule arise until some time—often years—has elapsed, and they may be regarded as an attempt on the part of the damaged joint to accommodate itself to the altered mechanical conditions.

Geographical distribution

Osteoarthritis is commoner in temperate and sub-temperate zones and becomes less frequent towards the polar regions and tropics. Northern European countries are more affected than the southern.

The sexes are affected to an approximately equal degree and the usual age of onset is in middle life, e.g. forty to fifty-five years.

Many of the causes remain undiscovered, and even in those cases in which the aetiology appears to be established, e.g. traumatic osteoarthritis, there is a lack of precise knowledge about the exact manner in which the different factors act. For instance, the presence of a torn semilunar cartilage may be tolerated in one individual for many years without the onset of osteoarthritic changes in the knee-joint. I have operated upon cases in which recurrent attacks of 'locking' have occurred for fifteen or twenty years and have found no evidence of osteoarthritis, but in many other cases osteoarthritic changes have been present in young persons with a short history of recurrent 'locking'. Such cases are usually somewhat cursorily labelled 'traumatic osteoarthritis'. Another factor, at present unknown, is probably responsible for the early onset of osteoarthritis in some cases and its indefinite postponement in others.

Association with endocrine disorders

Osteoarthritic changes are more frequent in certain disorders of the ductless glands, such as acromegaly, than can be ascribed to coincidence. Whether in these cases the joint changes are due to the action of toxins formed from failure of the ductless gland to supply the necessary link in the chain of metabolic endogenous products, or whether in some way the resistance of the joint to bacterial toxins is lowered, it is at present impossible to decide. The relation of osteoarthritis to the group of auto-intoxications due to defects in the excretory apparatus or the accumulation in the body of products of normal metabolism is still undecided. In spite of these undecided factors the aetiology of some groups is better known.

(2)—Classification (based upon that of the British National Committee on Chronic Rheumatic Diseases)

Of known aetiology are those forms which are (*a*) secondary to trauma, (*b*) secondary to many other forms of arthritis particularly of the rheumatoid type, (*c*) associated with disordered metabolism (climacteric, gout, scurvy, haemophilia), and (*d*) associated with organic disease of the nervous system (e.g. Charcot's joints and syringomyelia); but the aetiology of (*e*) the so-called 'senile' form (e.g. morbus coxae senilis) is unknown.

(*a*) *Traumatic or Localized Osteoarthritis*

Varieties

Varieties: (1) The presence within the joint of a loose or foreign body, or some focus of irritation in the adjacent bone, such as a retained projectile, a chronic abscess or new growth. (2) Alteration of alignment due to fracture actually involving the articular surface. (3) Malunited fractures or diseases of the limb bones, which have brought about deformity with resulting abnormal stresses upon adjacent articulations. Ankylosis of a neighbouring joint may act in a similar way. (4) Abnormal articular strains and stresses from occupational causes or due to incorrect posture. (5) Unreduced dislocations, congenital or acquired. (6) Osteoarthritis in false joints or following arthroplasty. (7) Repeated attacks of synovitis, especially when synovial chondromas or hypertrophied fringes are present. (8) Abnormal joint mobility due to torn or stretched ligaments. (9) Following a severe haemarthrosis or the repeated intra-articular haemorrhages of haemophilia.

A few examples of some of these varieties will serve to show that traumatic osteoarthritis is often preventable by appropriate early treatment of injuries. For instance, osteoarthritic changes frequently supervene in the knee-joint if a torn semilunar cartilage is allowed to remain and to give rise to recurrent attacks of locking, pain, and effusion. Operation in experienced hands is the best insurance against the onset of these changes, and the results of modern surgery are so good that this should always be advised unless some special contra-indication is present.

In fractures involving the joint surfaces, every effort should be made to ensure accurate apposition, which may necessitate mechanical fixation by plate, bone-graft, or screw. In this connexion, it is interesting to note that certain diseases of early life such as Perthes's disease of the hip-joint, which bring about changes in the shape of the articular surface, are apt to be followed in later life by osteoarthritic changes.

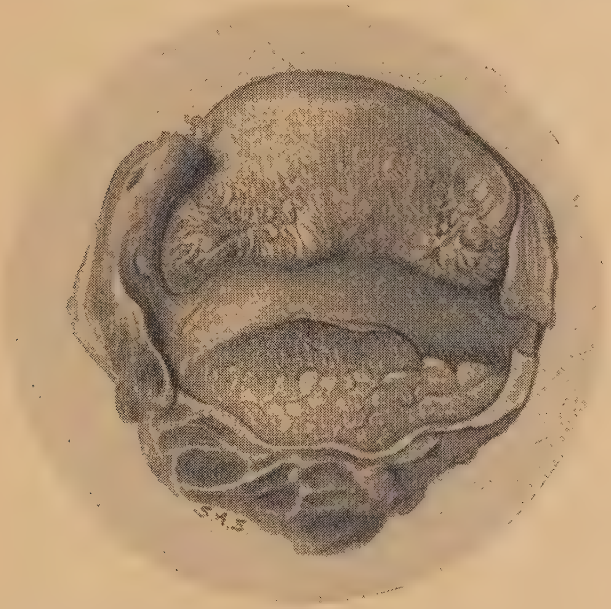

FIG. 23.—Early osteoarthritic changes in association with fracture of patella (*Lancet*, 1922)

Fracture of the long bones

It is just as important to secure accurate alignment in fractures of the shafts of the long bones and in fractures in the neighbourhood of joints. For instance, malunion after Pott's fracture is often followed by osteoarthritic changes in the ankle-joint. Similarly the prevention of deformity must be aimed at in diseases of the bones associated with softening. The possibility that ankylosis of a joint may bring about increased strain and stress in some adjacent joint must be considered before deciding upon an operation to bring about ankylosis such as may be thought advisable in some cases of chronic arthritis. For instance, the operation of arthrodesis of the hip-joint may be necessary in exceptional cases for the relief of an acutely painful type of arthritis. If successfully performed, it relieves all pain in the affected hip, but it is apt to be followed by chronic sacro-iliac or lumbo-sacral strain and even by the development of osteoarthritis at these sites.

Influence of strains and stresses

The influence of abnormal strains and stresses in the production of chronic arthritis of the osteoarthritic type is well seen in some occupations and to this factor Lane was the first to direct attention. He showed that the skeleton, when exposed to abnormal mechanical conditions, underwent marked and definite changes which were previously regarded as evidence of disease. According to van Breemen many different trades and occupations favour the development of osteoarthritic changes in specific regions. The importance of incorrect posture in the development of osteoarthritic changes has not as yet received the attention that it deserves. It is quite exceptional to observe correct posture, and it may well be that the belated interest now taken in this problem may exert a beneficial effect upon the incidence rate of osteoarthritis. Osteoarthritis following unreduced dislocation is exemplified by the onset of such changes in long-standing cases of congenital dislocation of the hip-joint.

(*b*) *Osteoarthritis secondary to other Forms of Arthritis particularly of the Rheumatoid Type*

This aspect of the subject is considered below (p. 97), and it will be sufficient to state that any form of arthritis, including 'rheumatoid arthritis', which has not been followed by ankylosis may be followed by so-called osteoarthritic changes which are often reparative or compensatory.

(*c*) *Osteoarthritis associated with Disordered Metabolism (Climacteric, Gout, Scurvy, Haemophilia)*

It is probable that disordered endocrine function plays an important part in certain forms of chronic arthritis of the osteoarthritic type, particularly in the form occurring in many women at the menopause. Similar forms may occur in younger women after artificial production of the menopause and in some endocrine disorders. Llewellyn and others have pointed out that the joint changes in this climacteric or hypoglandular type of arthritis are often associated with other manifestations of a widespread metabolic disturbance. He pointed out that osteoarthritis is not uncommon in sufferers from endemic goitre, that thyroid is of benefit in these cases, and he agreed with McCarrison that the incidence of osteoarthritis is greater in regions where goitre is endemic.

(*d*) *Osteoarthritis associated with Organic Disease of the Nervous System (Charcot's Joints and Syringomyelia)*

In these diseases the joints may be the seat of pathological changes which, except that all such processes are greatly exaggerated, are similar to those seen in the osteoarthritic type. The cause of these exaggerated osteoarthritic changes is at present unknown.

(*e*) *So-called 'Senile' Osteoarthritis*

This is extremely common after middle age. In fact, systematic examination of the joints after death usually reveals some degree of degenerative change in the joints of most persons over fifty years of age and often in those considerably younger. Although it is in some ways a plausible view that the 'senile' form of osteoarthritis is due to interference with nutrition resulting from arteriosclerosis of articular vessels, the theory is not supported by examination of early cases, the blood-vessels never showing arteriosclerotic changes when the earliest signs of degeneration of the articular cartilage first become manifest. In the later stages, arteriosclerosis is usually present and may hasten the progress of the disease. Toxic foci are often associated with osteoarthritis of this type but at present it is impossible to argue logically that they are of aetiological importance. Glover has pointed out that 75 per cent of the population over the age of 40 have septic teeth, yet this percentage greatly exceeds that of the actual sufferers from osteoarthritis with clinical manifestations, although, as has been pointed out above, early degenerative changes are often symptomless.

3.—PATHOLOGY

(1)—Osteoarthritic Type (Hypertrophic Degenerative)

Inflammatory and degenerative changes in the cartilage

The first change consists in a degeneration of the central area of the articular cartilage. Subsequent changes in a sense are all consequent upon this primary degeneration—although they are more inflammatory than degenerative. For instance, the lateral part of the cartilage proliferates, and osteophytes are formed to extend the articular area. The subchondral layer of bone becomes sclerosed, hardened, and eburnated in an endeavour to form a new joint-surface and thus compensate for the loss of the central portions of the cartilage. The changes in the synovial membrane are at first insignificant. There is villous hypertrophy and increased vascularity of the synovial fringes near the articular margins. Later, however, the synovial membrane and capsule become thickened and fibrous and arteriosclerotic changes may then be seen therein. It appears, however, that these occur concurrently and are not of aetiological importance.

Histological changes

The histological changes in the synovial membrane and capsule are of the nature of an inflammatory hyperplasia, and an important point is that collections of small-celled infiltration, which are frequent in the rheumatoid type, are usually absent. These changes are frequently seen at necropsy in the joints of persons past the meridian of life and are common as the result of trauma or long-continued intra-articular irritation. The term degenerative may be logically applied to this type as it is at any rate the primary change.

The association of degeneration and hypertrophy that occurs in the osteoarthritic type, whether primary or secondary, is probably due to the fact that the lateral portion of the articular cartilage receives an additional source of nutrition in the circulus articuli vasculosus, and thus responds to any given irritation by hypertrophy, whereas the response of the poorly nourished central areas of the articular areas of the articular cartilage is of a degenerative nature (see Fisher, 1922).

Chronic gout In chronic gout the joint changes are usually, but by no means invariably, of the osteoarthritic type. The pathological changes are similar, therefore, to those described above with the important addition of deposits of sodium biurate in the constituent elements of the joint. In addition to uratic deposits in the articular cartilage, synovial membrane and capsule, and in periarticular structures, collections of the crystals of sodium biurate often occur occupying cystic spaces or 'punched-out' areas in the subarticular cancellous tissue.

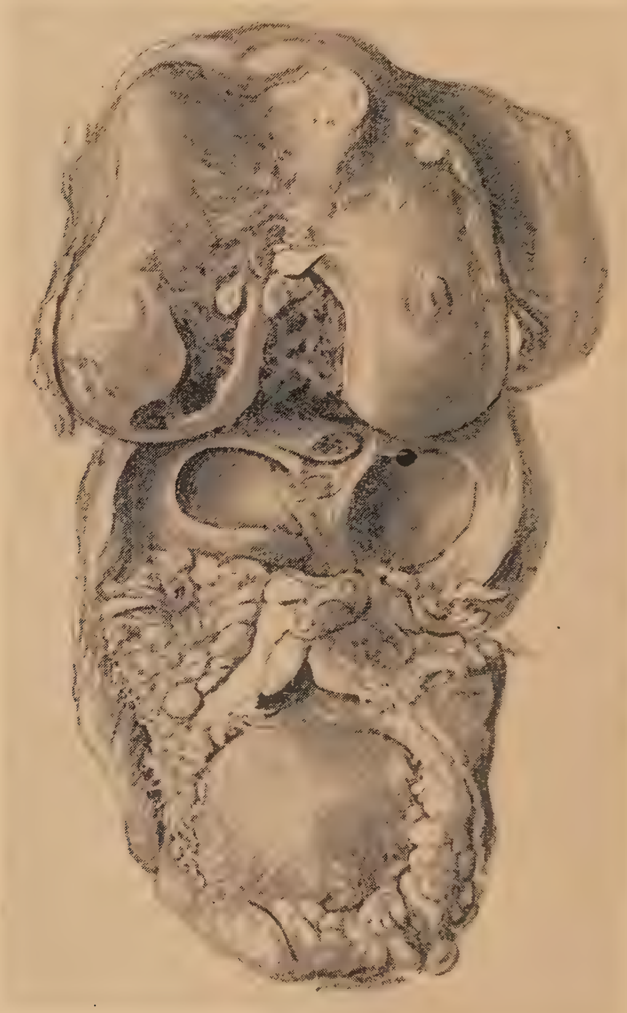

FIG. 24.—Osteoarthritic changes in knee-joint in congenital syphilis
[From the Author's *Chronic (Non-Tuberculous) Arthritis*]

(2)—Osteoarthritic Changes superimposed on Other Forms

It is most important to realize that in addition to *primary* osteoarthritic changes, such as have been described above, somewhat similar *secondary* changes may be superimposed upon other forms of arthritis, particularly of the rheumatoid type, in the later stages. For instance, the majority of the specimens of 'rheumatoid arthritis' in the Strangeways collection at the Royal College of Surgeons of England were obtained after death from persons who had suffered for many years, and many of these specimens show *secondary* osteoarthritic changes. The latter changes are the physiological response of the elements of the joint to the damage inflicted by the previous rheumatoid type of disease and may be regarded in some ways as crude attempts at repair. Similar secondary osteoarthritic changes may sometimes be seen in due course after suppurative forms of arthritis from which the patient has recovered, and in which a certain amount of joint movement has persisted.

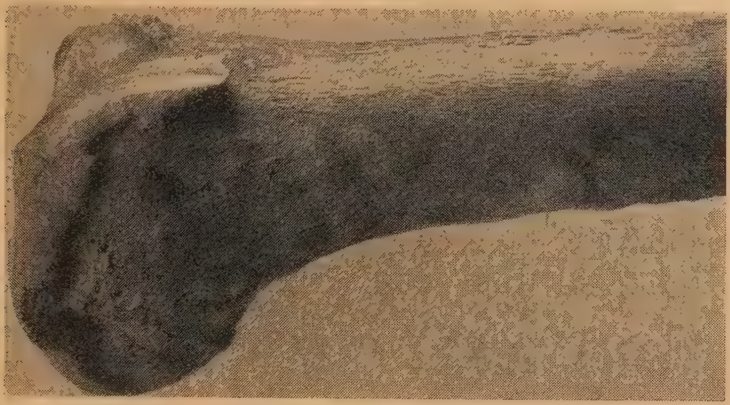

FIG. 25.—Lower end of femur from an Egyptian of the 17th Dynasty exhibiting osteoarthritic changes, also ossifying periostitis of lower end of shaft of femur (*Lancet*, 1922)

4.–CLINICAL PICTURE

(1)—Onset and Symptomatology

Onset

The onset of osteoarthritis is usually insidious and afebrile, differing thus from the rheumatoid type which not infrequently has an acute onset. So gradual and symptomless may be the onset that the patient does not complain of pain or stiffness and therefore does not report for treatment until the disease is well established.

It is interesting to note that, if the joints are affected symmetrically, although a patient may seek advice concerning one knee, the X-ray examination may reveal that the changes are actually more marked in the other knee-joint which is comparatively free from symptoms. It is thus clear that the onset of symptoms does not present any definite relation to the degree of osseous change but depends rather upon the state of the connective-tissue elements of the joint.

Joints affected

Osteoarthritis is more often monarticular, thus differing from the rheumatoid type of chronic arthritis. Polyarticular forms not infrequently occur, but in these there is not the frequency of the symmetrical distribution usual in the rheumatoid type. The knee-joints are most frequently affected in women and the hip-joints in men. In the polyarticular forms the distribution is characteristic. In the hands, for example, osteoarthritis frequently involves the carpo-metacarpal joints of the thumbs (thumb-base arthritis) and the terminal interphalangeal joints (Heberden's nodes), and these joints are but seldom involved in the rheumatoid type of arthritis.

Swelling

The enlargement and alteration in shape of the osteoarthritic joint are due principally to changes in the articular ends themselves, and particularly to periarticular lipping, which is one of the most characteristic features. Changes in the capsule and periarticular structures are not prominent, and hence the spindle-shaped appearance so typical of rheumatoid arthritis is never seen in osteoarthritis. The arthritis is usually of the dry type (*arthrite sèche*), and synovial effusions are rare except in the earlier stages. Cysts containing mucoid fluid may be present in the vicinity of the affected joints (Baker's cysts). Harsh crepitus can usually be elicited on movement, and enlarged synovial fringes may be present in the vicinity of the articular margins, but never to the same extent as in the villous variety of the rheumatoid type.

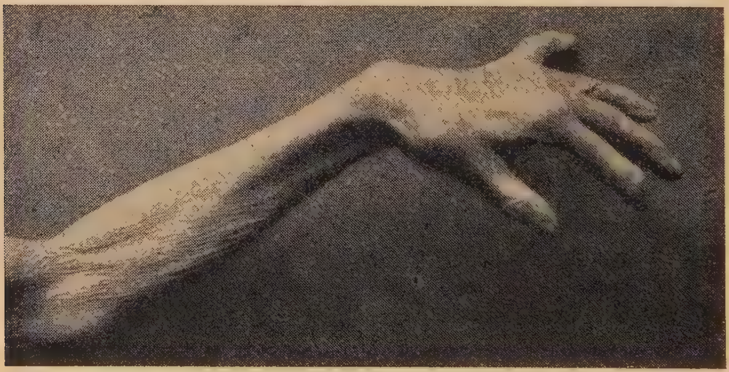

FIG. 26.—Osteoarthritic changes in wrist-joint simulating dislocation. Note also the marked thickening of the carpo-metacarpal joint of the thumb and a Heberden node in the index finger

[From the Author's *Chronic* (*Non-Tuberculous*) *Arthritis*]

Muscular wasting

Wasting of the muscles moving the affected joint is prominent in the majority of cases. This wasting is due partly to a disinclination to use the limb owing to pain, and partly to reflex action. The latter acts through impulses from the irritated articular nerves, which interfere with the trophic action of the anterior cornual cells. The muscular wasting in the osteoarthritic type is not as a rule so marked as in the more acute rheumatoid type, because active movements are rarely completely inhibited.

Pain

In some cases osteoarthritis may give rise to no pain or symptoms of any sort, and its presence in a joint is compatible with a considerable degree of activity. In others, in which the clinical and radiographic signs are slight, symptoms may be prominent. There is therefore no definite relation between the degree of the changes and the symptoms.

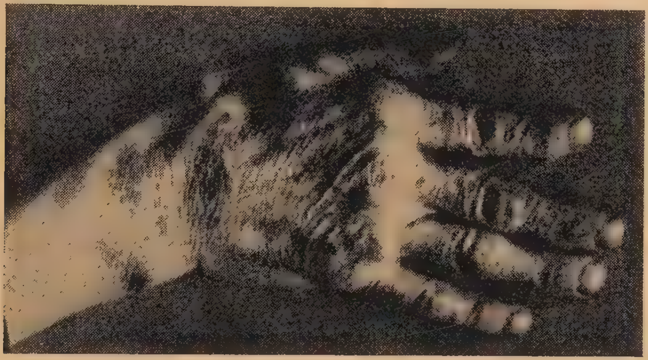

FIG. 27.—Osteoarthritic changes in joints of hand with Heberden's nodes
[From the Author's *Chronic (Non-Tuberculous) Arthritis*]

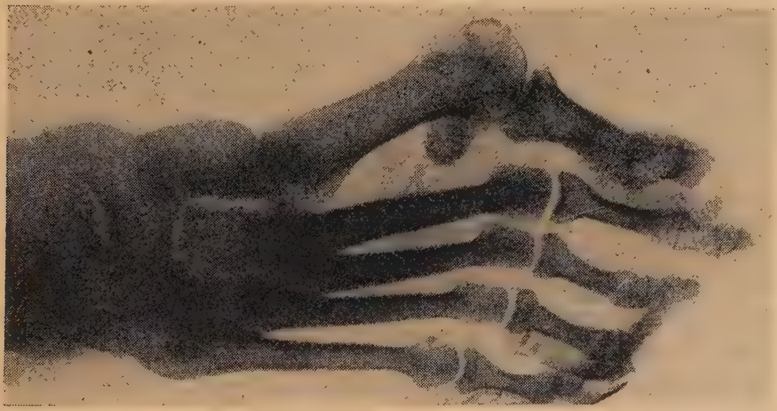

FIG. 28.—Characteristic X-ray appearance of foot in osteoarthritis: toes deviated outwards at metatarso-phalangeal joints, pronation at mid-tarsal joint with consequent flat-foot
[From the Author's *Chronic (Non-Tuberculous) Arthritis*]

The joint is often stiff in the morning but its condition is improved by moderate exercise; towards the end of the day, however, and after more prolonged use, the joint aches and the whole limb feels heavy.

Referred pains are often a well-marked feature. For instance, in osteoarthritis of the hip-joint pains referred along the course of the sciatic or anterior crural nerves are often present, and an X-ray of the hip-joint should always be taken in every case of 'sciatica'. Radiographic examination often reveals that a case of 'neuritis' is really one of osteoarthritis with referred pain.

Limitation of movement and deformity

True ankylosis, or union by fibrous tissue or bone between opposed articular surfaces, although frequent in rheumatoid arthritis never occurs in true osteoarthritis. The limitation of movement that occurs in osteoarthritis is due to osteophytes, to capsular and ligamentous contractures, and to muscular spasm which, in the later stages, is associated with actual shortening of periarticular tendons. In rheumatoid arthritis deformity is primarily due to muscular spasm, but may become 'fixed' by the formation of scar tissue in or around the joint capsule or by true ankylosis.

(2)—Table of Characteristic Types of Deformity compared with Positions of Election for Ankylosis (Spine not included)

DEFORMITY	POSITION OF ELECTION FOR ANKYLOSIS
HAND.—Ulnar deflection of fingers at metacarpo-phalangeal joints. Well-marked flexion at interphalangeal joints, sometimes hyperextension at proximal interphalangeal joints	Moderate degree of flexion at metacarpo-phalangeal and interphalangeal joints. Absence of lateral deviation
WRIST.—Flexion	Extension through 45°
ELBOW.—Usually midway between flexion and extension; forearm in pronation	Varies according to occupation and patient's wishes. Probably slightly less than 90° best. Forearm midway between pronation and supination
SHOULDER. — Flexed, adducted, and rotated inwards	Slight flexion; abduction through 45° (adults) or 70° (children)
FOOT.—Hallux valgus or rigidus. Toes deviated outwards at metatarso-phalangeal joints. Pronation at mid-tarsal joint with consequent flat-foot	The normal position. Slight inversion is sometimes advantageous
ANKLE.—Plantar flexed	Foot forms an angle of 90° with leg. A few degrees of dorsiflexion sometimes preferable
KNEE.—Flexed. In severe cases tibia is subluxated backwards and rotated outwards	Complete extension, although if ankylosis is bony, a few degrees of flexion may be of advantage
HIP.—Flexed, adducted, and rotated inwards (late stages)	Slight abduction and rotation outwards in extension

(3)—Osteoarthritis of the Hip-Joint (Morbus Coxae Senilis)

(a) *General Symptomatology*

This form is usually seen in males over forty years of age and is more often unilateral. There is often a history of injury, but this is usually of a moderate degree of severity only and precedes the onset of arthritis by a considerable period. Pain is slight at first and may be felt not only near the joint, in the groin, or the buttock, but also in the trochanteric region, the leg, or thigh. In the latter event a diagnosis of sciatica is often made. The pain is aggravated by excessive exercise and is usually more severe at the end of the day. Stiffness is progressive in untreated cases; at first it is due to spasm of muscles, but later to capsular and periarticular scar-tissue or to osteophytes. Rotation at the joint is first affected, then the movements of abduction and adduction, and finally those of flexion and extension.

(b) *Deformity*

Stage of apparent lengthening

The apparent lengthening of the lower extremity on the affected side is due to the fact that in the early stages the limb is abducted, and to maintain the parallel position of the lower extremities, the pelvis is tilted downwards on the affected side producing also a lumbar scoliosis with convexity towards the affected side. In this stage the thigh is also slightly flexed and this deformity is marked by lumbar lordosis. Rotation of the limb outwards is present.

Stage of apparent shortening

In later stages, flexion at the hip-joint and lumbar lordosis increase, and owing to spasm of the more powerful adductor group, the thigh becomes adducted. To maintain the parallelism of the limbs, the pelvis is tilted upwards on the affected side, thus bringing the adducted limb into line with its fellow. Thus the lower extremity on the affected side now appears to be shorter than its fellow, although they are actually equal in length.

Stage of real shortening

Later on, owing to destructive changes in the femoral head and in the acetabulum, real shortening of the affected limb occurs. The pelvic tilting and lumbar scoliosis become more prominent from increased adduction of the thigh. Flexion of the thigh often becomes so marked that it can no longer be hidden by lordosis, and the limb becomes internally rotated. The summit of the trochanter is raised above Nélaton's line. Owing to the coexistent apparent shortening the amount of real shortening is always less than appears at first sight.

Radiographic appearances

Unfortunately the very earliest stages, in which treatment is likely to be of most benefit, cannot be detected radiographically. Slight abnormal translucency of the articular extremities from atrophy of cancellous tissue and early periarticular lipping are the first X-ray evidence obtainable. In the knee-joint, a 'spiky' appearance of the tibial spine is often an early sign. 'Lipping' occurs earlier in the joints of the lower extremity, and in the shoulder its appearance usually indicates a somewhat developed stage.

In the later stages, narrowing of the joint-interval increases; the articular bone becomes sclerotic; and periarticular lipping more prominent. Cyst-like spaces may be seen just beneath the articular surface and loose bodies formed from detached osteophytes may occur. Sometimes the bones in the region of the joint may be the seat of ossifying periostitis.

5.–DIFFERENTIAL DIAGNOSIS FROM CHRONIC RHEUMATOID ARTHRITIS

Age incidence

Rheumatoid type

The osteoarthritic type, although occasionally seen in young persons, is characteristically seen in those past the meridian of life, whereas the rheumatoid type is commoner in young adults or in early middle life, and usually starts in the smaller joints of the hands, particularly the proximal interphalangeal or metacarpo-phalangeal. The rheumatoid type is frequently symmetrical and spreads centripetally, the hip- and shoulder-joints being either unaffected or involved late in the disease. The onset is either acute or subacute. After a variable period, the symptoms diminish, but the condition smoulders on, and fresh outbreaks in the same or in different joints often occur. The joints have a globular or spindle-shaped appearance. True ankylosis may occur in acute cases.

Osteoarthritic type

The osteoarthritic type usually involves larger joints such as the hips and knees. When it is polyarticular, the terminal interphalangeal or carpo-metacarpal joints of the thumbs are often involved. The changes are osseous rather than synovial, and harsh crepitus is a prominent feature. True ankylosis does not occur in uncomplicated cases. From study of the age incidence, distribution, pathological changes, and clinical signs and symptoms it is clear that chronic arthritis is divisible into one or other of these great clinico-pathological groups.

6.–TREATMENT

(1)—Prophylaxis

The traumatic form is largely preventable by appropriate early treatment of injuries such as fractures, the accurate alignment of the fragments being most important. Many cases of traumatic osteoarthritis of the knee-joint are due to the unwise policy of refraining from operating upon a torn semilunar cartilage which is giving rise to recurrent attacks of pain, effusion, and locking.

Many sufferers from osteoarthritis are plethoric, overweight, have high blood-pressure, and either take little exercise, or do so irregularly and crowd it into the week-end. Overweight must lay burdens upon the joints, particularly of the lower extremity, for which they are not intended, and is a potent cause of osteoarthritis. Incorrect posture and particularly the syndrome of round shoulders, pendulous abdomen, lumbar lordosis, knock-knee, and pronated foot are much too common and, if neglected, may be a direct or predisposing cause of osteoarthritis.

In the idiopathic or 'senile' types presumptive evidence exists that long-continued toxic absorption plays a part. The importance therefore of prompt treatment of foci of toxic absorption needs special emphasis in view of the fact that such foci often do not appear to the patient to cause sufficient trouble to warrant the seeking of advice. Much therefore can be done to prevent certain types of osteoarthritis by proper observance of the laws of health and the cultivation of the 'mens sana in corpore sano'.

(2)—Methods of Physical Medicine

Many of these are of value in all stages, but care is needed in their prescription and administration. In the earlier stages, they are often of great benefit combined with dietetic and medicinal measures. In the later stages, they may be advantageously used in conjunction with the orthopaedic and surgical measures described below.

(*a*) *Heat*

Heat may be applied to the affected joints in many ways, convenient methods being hot baths, including the methods of hydrotherapy of certain spas, applications of hot wax, radiant heat, infra-red rays, and diathermy; and for poor people treated at home, the application of hot salt bags or fomentations.

(*b*) *Massage and Bathing*

Massage of the affected limb is often helpful if properly administered. When gentle, superficial, and rhythmical (effleurage), it allays painful muscular spasm. It also acts mechanically by relieving congestion and improving the circulation of the joint, by assisting lymphatic flow, and by dispersing waste products or the products of inflammation. Massage may be preceded by the administration of heat, and both are useful preliminaries to active and passive movements and muscular re-education. In osteoarthritis of the hip and certain other joints, active and assisted movements in the deep pool are of value, the hot water relieving the muscular spasm and helping to support the limb. The patient thus finds it possible to carry out movements and exercises hitherto impossible owing to pain and muscular spasm.

(*c*) *Use of Apparatus*

In some cases of osteoarthritis, particularly in the weight-bearing joints such as the hip or knee, and when pain on exercise is a prominent feature, an attempt may be made to relieve intra-osseous pressure by some form of 'de-stressing' apparatus to enable the patient to take exercise. Most of these are constructed after the Thomas splint pattern. In applying extension to the hip or knee the principal *point d'appui* above should be the ischial tuberosity. The lateral steel supports are made a little longer than the limb and terminate in right-angled pieces that fit into the heel of the patient's shoe. The heel is separated by a short space from the inner surface of the heel of the shoe so that in standing or walking extension of the limb and separation of the sensitive joint surfaces is brought about. A locking device can be introduced at the level of the knee-joint to enable the patient to sit in comfort.

(*d*) *Active and Passive Movements and Muscular Re-Education*

Patients often state that the stiffness and discomfort of the affected joint are most marked early in the morning or after sitting for any length of time, and that the stiffness becomes less after use. It is clear therefore that carefully graduated movements are beneficial, and exercise up to a point should be encouraged. Such exercise often has an excellent effect upon the patient's general health and militates against increasing weight, thereby helping to destroy a vicious circle. An important principle is that the affected joints must be put through their full range of movement daily to prevent deformity by scar-tissue or osteophytes, and that a few special exercises should be performed daily by the patient to prevent as far as possible the wasting of the muscles acting upon the joint, which is otherwise such a prominent feature. Faradic stimulation is of value in the restoration of muscular tone.

(*e*) *Manipulation*

This measure is of distinct value, particularly in comparatively early cases, in which the movements of the joint are restricted by scarring of the joint-capsule or contracture of periarticular tendons and ligaments rather than by osteophytes or alteration in the shape of the articular surfaces. It will often be found in such cases that the limitation of movement interferes seriously with the function of the limb. By careful manipulation under anaesthesia, provided the age and general condition of the patient permit, it is often possible to improve the range of movement and the functional capacity of the limb. The after-treatment is most important and consists in the maintenance of the increased range of movement by regular and systematic exercises. The method is valuable in osteoarthritis of the hip-joint in the earlier stages before gross changes have occurred. The duration of the benefit depends largely upon the willingness of the patient to co-operate in the maintenance by his own efforts of the increased range of movement obtained by the manipulation, and the improvement may last for several years.

(3)—Surgery

Two types of operation

Operations for osteoarthritis may be divided into those which aim at the retention of movement in the affected joint and those which aim at deliberate fixation of the joint. Retention of movement, provided this is associated with stability, is usually the operation of choice, but cases associated with gross destructive changes or acute and persistent pain may demand an ankylosing operation.

Removal of loose bodies

A detached osteophyte may excite acute symptoms in a joint such as the knee, and operation for its removal may be necessary.

Excision

When pain is severe or gross deformity and disorganization present, excision may be necessary. In the knee, where stability is usually the first consideration, ankylosis in the optimum position is usually sought, and the operation results in a painless and stable, but fixed joint.

Arthroplasty

In the case of the hip, shoulder, elbow, and metatarso-phalangeal joint of the great toe the operation aims at a movable joint. This procedure is somewhat disappointing in the present state of our knowledge and technique, owing to the tendency to ankylosis of the new joint and to the onset of osteoarthritic changes therein. It is indicated in certain cases of bilateral ankylosis; for instance, two stiff hips, elbows, or knees, or combinations of hips and knees, in one individual, warrant an attempt to restore movement on one side.

Arthrodesis

Arthrodesis aims at the formation of artificial ankylosis of a joint and is most often performed in the case of the hip-joint. There can be no doubt that a satisfactorily performed operation gives almost complete relief from pain and increases stability. The operation is a severe one and unfortunately is apt to be followed after a variable period by symptoms referred to the lumbar spine and sacro-iliac joints.

Osteotomies

Osteotomies may be necessary to correct deformity. The bifurcation operation of Lorenz for osteoarthritis of the hip falls within this category.

Limitations of surgical measures

Surgery is often valuable in the treatment of osteoarthritis, but it should be remembered (1) that many sufferers are elderly and unsuitable subjects for surgery, (2) that with more enlightened treatment in the earlier stages the question of surgical measures would never arise, and (3) that a fair trial should always be given to modern methods of physical medicine and, in particular, to careful manipulative treatment before having recourse to surgery, because by perseverance in these methods the condition of the patient can often be greatly improved.

V.—SPONDYLITIS

101.] Spondylitis is generally regarded as arthritis of the vertebral column, but although the same general principles apply in its treatment there are important differences. There are two principal forms: (1) ankylosing spondylitis or *spondylose rhizomélique*, and (2) osteoarthritis of the spine.

1.–ANKYLOSING SPONDYLITIS

(1)—Definition

Ankylosing spondylitis is generally a disease of early adult life, but the premonitory symptoms may appear as early as sixteen or seventeen years of age, and on the other hand the typical ankylosis may not develop until middle life. It is characterized by a steady and relentless progress to complete ankylosis of the spine and the larger joints, following a centrifugal course. The spine may be quite rigid within a couple of years of the first appearance of symptoms, or there may be fluctuations, periods in which the disease ceases to progress, the pain disappears, and the stiffness improves to a degree which would be thought impossible both clinically and radiologically. Then something occurs to reduce the patient's resistance, a shock, an injury, an attack of influenza or other debilitating disease, and the process again flares up, this time perhaps not to die down until the spine, hips, shoulders, and sometimes other joints, are fused into a rigid bar. This may be straight, or distorted into grotesque shape according to whether the patient has been kept in bed or has been moving about to the best of his limited ability.

(2)—Aetiology

The cause of spondylitis is unknown, but undoubtedly it is infective. A streptococcus derived from some septic focus is commonly suspected; but on the other hand some incriminate an attenuated form of the tubercle bacillus, and probably more factors than one—toxic, infective, or physical—combine to produce the disease. The gonococcus is certainly responsible for some cases of arthritis of the spine, but in the light of modern knowledge it is doubtful if it causes ankylosing spondylitis. It will generally, if not always, be found that when gonorrhoea has been present the small joints are first affected and, at a later stage, the spine. But in true spondylitis the progress is always from the spine to the large joints in a regular centrifugal course; and although in the premonitory stages fleeting pains and even swelling of small joints may occur they always clear up when the spine becomes definitely affected.

The gonococcus

Rheumatic history

A history of rheumatic fever or subacute rheumatism is met with in a certain number of cases, perhaps as many as 20 per cent, but as the premonitory symptoms include pain in the joints it is probable that this accounts for some of these cases.

Influence of spinal injury

Injury to the spine sometimes appears to be a factor; and I have met with several cases in which the symptoms began very shortly after a blow on the spine, but probably this was only the exciting factor, the causal infection being already present in the system.

(3)—Morbid Anatomy

There is reason to believe that the disease commences in the bones in the region of the joints, or in the bodies of the vertebrae, and then spreads to the joints. It has been demonstrated that micro-organisms in the blood-stream tend to be filtered out by the bone marrow and can often be found there after injection into the blood-stream experimentally. The epiphysial and sub-epiphysial regions appear to be specially affected, and similarly the vertebral bodies, as a result of which an epidural exudate may form. This exudate was noted by Hilton Fagge in 1877; he described a white mortar-like substance deposited on the outer surface of the arches and bodies of the vertebrae. The appearance thus produced has been compared with the wax dripping down the side of a guttering candle, and has been erroneously attributed to ossification of the anterior common ligament; it is more frequent on the lateral than on the anterior aspects of the spine. Periosteal new-bone formation is often seen in the pelvis especially at the attachment of muscles and ligaments; it arises in the same way. Rarefaction of the bones in these regions is a characteristic feature; they may become so soft that they can be cut with a knife. The ligamentous structures ossify, particularly those of the sacro-iliac joints and the joints of the articular processes of the vertebrae; and the ossifying process extends to the outer part of the intervertebral discs, so that the bodies of the vertebrae become joined together.

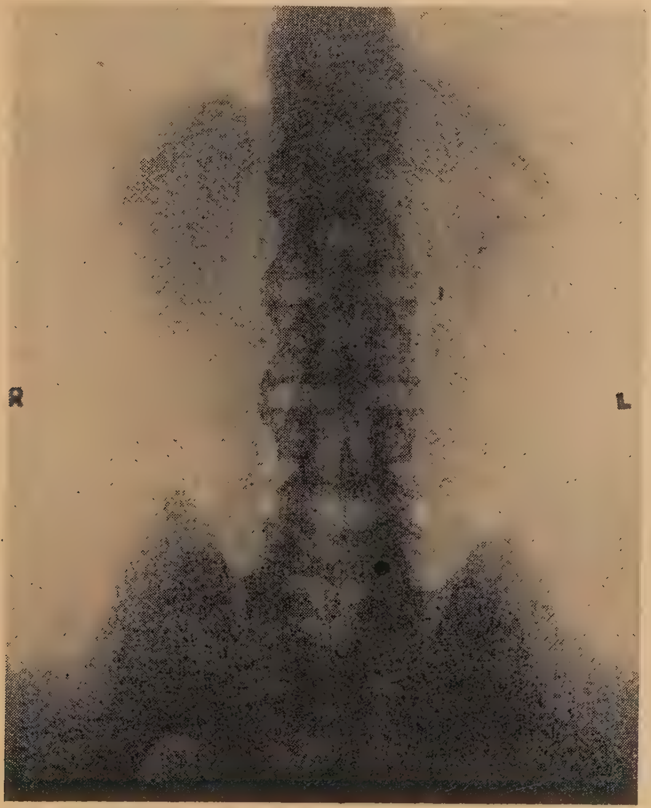

Fig. 29.—Ankylosing spondylitis showing ossification of intervertebral discs: 'tram-line' appearance due to ankylosis of the articulations between the articular processes, and ankylosis of the sacro-iliac joints

In the great majority of cases ankylosis of the sacro-iliac joints is one of the earliest signs. Loss of density in the vertebral bodies with parallel lines of greater density, due to the ossified intervertebral joints, and often thickening of the spinous processes and ossification of the posterior spinous ligaments, gives a striking picture in the radiograph.

As ossification spreads into the discs they become denser, the contrast with the bodies is lessened, and the appearance known as the 'bamboo spine' results.

The costo-vertebral joints are affected in the same way; the patient may be unaware that thoracic respiration is lost till his attention is directed to it in the course of examination. In the great majority of the cases the lumbo-sacral region is the first to be affected, and the disease spreads steadily upwards to the dorsal and cervical regions, and to the hips. In a few cases the neck is first affected, the progress is then outwards to the shoulders and down the spine. Occasionally the mandibular and the sterno-clavicular joints are affected.

(4)—Clinical Picture

Pain is often severe in the early stages but lessens as the stiffness develops; it is largely due to attempted movement of the affected joints. When ankylosis is complete, pain may be absent except in the very rare cases in which the spinal foramina are encroached on by periosteal exudation or by excessive curvature. There may be a slight evening rise of temperature in the more acute phases of the disease but this is never a prominent feature.

There is a moderate degree of muscular wasting which affects the muscles acting on the damaged joints, but there is little constitutional disturbance. The softening of the bones tends to cause various forms of curvature of the spine, but ossification of the ligaments, especially those of the articular processes, the costo-vertebral joints, and the posterior spinous ligaments tends to limit this process. Kyphosis may thus occur in the dorsal and cervical regions and the head may sink forward till the chin touches the sternum and becomes fixed in this position. In advanced cases the mandibular joint may become ankylosed to a great extent; the shoulders are usually greatly limited in movement and the hip-joint may become completely obliterated, the spongiosa of the innominate bones becoming continuous with that of the femora. Since the ankylosis is due in the first instance to ossification of the ligaments some cartilage may be preserved in the interior of the joints. The central nucleus pulposus of the intervertebral discs always escapes ossification which is limited to the outer margin only. The knees and elbows are rarely completely ankylosed, and any advanced changes in the joints of the hands and feet would suggest that the case is not one of true ankylosing spondylitis but rather of an infective arthritis extending to the spine as may occur in gonorrhoea.

(5)—Course and Prognosis

Spondylitis is not likely to prove fatal by itself but death may result from intercurrent conditions. Thoracic rigidity may favour bronchopneumonia; or there may be bedsores, due to deformity so great that the patient cannot stand without support or lie on his back.

Intermissions Intermissions commonly occur and after an active phase during which the lumbar spine and hip-joints become ankylosed there may be a quiescent period of many months or years during which the range of mobility may increase. Then pains such as heralded the original onset appear in various parts, gradually concentrating it may be in the dorsal and cervical region and the ankylosing process again becomes active. In this way the whole spine becomes rigid, straight, or distorted, the shoulders limited, the thorax fixed, the hips and even the knees ankylosed, and often almost complete fixation of the mandibular joints completes such an appalling picture that death is welcomed.

(6)—Diagnosis

Differential diagnosis in a typical case should not present any difficulties, but radiological examination is essential to recognize the disease in the earliest stage when treatment may prove effective in arresting its progress and limiting the deformity.

Diagnosis from adolescent kyphosis

Adolescent kyphosis may present difficulties, especially in those forms of comparatively sudden onset accompanied by pain. This condition, however, always attacks the lower dorsal region, a site I have never seen affected in early spondylitis without more marked evidences in other parts of the spine. There is no marked osteoporosis shown in the radiograph and no indication of ankylosis although the kyphosis cannot be straightened out.

From tuberculosis

Tuberculosis is usually more localized, marked tenderness of one or more of the spinous processes can be elicited and localized pain on pressure on the vertex in the erect posture or jarring on the spine by dropping on the heels. Angular kyphosis often develops early, whereas kyphosis in spondylitis is not angular and is usually slower in appearance. Tuberculosis of the sacro-iliac joint may cause much doubt, although the localization of pain to the sacral area, and possibly along the sciatic nerve, together with tenderness of the sacro-iliac joint, will help. A good radiograph interpreted by a competent radiologist should settle the question. Diagnosis should be clear from the constitutional symptoms and radiographical appearances.

From typhoid spine

Typhoid spine is a localized osteomyelitis, in which pain is usually very much more severe than in ankylosing spondylitis. The history of an attack of enteric fever, the acute localized pain, and the X-ray appearances should clear up any difficulties.

From spondylitis osteo-arthritica

Spondylitis osteoarthritica may present great difficulty in cases originating in middle life. Pain and stiffness may characterize either condition, but the symptoms will generally be more severe in the ankylosing form, though this may be slow and insidious, and medical aid may not be sought until bony changes are fairly advanced. There will be no osteoporosis; the linking of the vertebrae is by fusion of exostoses and not by ossification of ligaments or discs; and the sacro-iliac joints will rarely be completely obliterated in the osteoarthritic form. Evidence of osteoarthritis will always be found in other joints, especially in the hands, knees, or hips.

From infective arthritis of the spine Arthritis of the spine from gonorrhoea or other infective foci will almost invariably be preceded or accompanied by arthritis of small joints; the characteristic centrifugal spread of spondylitis is absent.

(7)—Treatment

Constitutional Treatment must be constitutional and local. Every attempt must be made to raise the patient's power of resistance, and infective foci must be searched for and dealt with even if they are not the cause of the disease. In fact, it is sound practice to treat the case as one of tuberculous infection with the addition of special methods suitable for the relief of pain and deformity.

Diet Damp houses and dark rooms must be avoided. Diet should be liberal and easy of digestion—plenty of milk, butter, eggs, and green vegetables preferably uncooked, and without any restriction of so-called acid fruits if they agree in other respects. An adequate vitamin content is of great importance, a proper balance between vitamins A, B, C, and D being essential. Yeast or marmite supplies vitamin B, and brown bread is better than white. Cod-liver oil of a reliable brand, or one of the concentrated sources of vitamins A and D now on the market, such as halibut-liver oil, improves resistance to catarrhal infections and counteracts the excessive calcium loss from the bones.

Drugs are of little service except as analgesics, but arsenic sometimes has a beneficial effect. Autogenous vaccine therapy is out of the question as the cause of the disease is unknown. The effect of other vaccines may perhaps be best regarded as an empirical method of stimulating bodily resistance, and for this purpose I have found the intradermal administration of preparations, such as the Ponndorf vaccine, of very real value; it is composed of bovine tuberculin together with an autolysate of Koch's bacillus, and in the B form, which I prefer, there are added streptococci, pneumococci, and the bacilli of influenza—a blunderbuss undoubtedly, but one of value.

Gold therapy Gold therapy (see p. 80) is also useful; it needs the greatest care, but is often effective. Constipation or evidence of intestinal auto-intoxication must be dealt with, sometimes lavage of the colon is helpful, and I find salol the most useful antiseptic.

Physical treatment Physical treatment is important, and the first care must be to prevent deformity. Rest in bed is desirable during the more acute stages and if kyphosis has begun to develop the patient should lie in a plaster shell as long as it can be tolerated. It should be made some degrees straighter than the curve which it is designed to correct, and, as the spine accommodates itself, cotton-wool pads which are used to adapt it to the patient's back must be gradually reduced, a fresh shell, which is still straighter, being made after a few weeks, and the process repeated until the spine has been brought as nearly as possible into the normal shape. Breathing exercises should be practised to maintain or increase the thoracic mobility. When the patient gets about again a suitable spinal support must be worn. The use of ultra-violet rays has a beneficial effect in raising the general resistance. Radiant heat—especially infra-red rays in moderation—combined with very light massage will relieve pain and stiffness.

Spa methods, particularly deep-pool baths where floating and swimming are possible, are very beneficial; and gentle douching of the spine by undercurrent methods is a valuable adjunct. Good results are claimed for deep X-ray therapy; this is not available for the majority of patients and should only be applied under expert direction.

2.—OSTEOARTHRITIS OF THE SPINE

Osteoarthritis of the spine is the same in its aetiology and pathology as osteoarthritis of other joints. It rarely gives rise to any notable symptoms and is chiefly of importance on account of its disabling effect on those whose work entails much strain or movement of the spine. It is consequently of some moment in compensation cases in which the problem may arise: 'Did the arthritis predispose to the injury, or did the injury cause the arthritis?' Arthritis of the spine is in the main a traumatic or degenerative process, but infective or toxic factors may sometimes lessen the capacity of the bones and joints to withstand wear and tear.

Association with chronic lumbago

It is characterized by a stiffness of the back that never amounts to complete rigidity; there is no great modification of the normal spinal curvature, flattening of the normal lumbar lordosis and a moderate stoop from an increased dorsal curve being usually the limit. When any effort is made, the limitation of movement may cause strain of the ligaments which are amply supplied with sensory nerve-endings; pain more or less severe and consequent disability result, disappearing with rest but liable to recur each time with less effort, and thus the patient becomes incapacitated for his usual work. This is probably the commonest cause of chronic lumbago.

The X-ray picture

The bony changes vary in degree as shown by radiography from a mere lipping of the edges of the bodies of the vertebrae to the formation of large exostoses which may join up with similar outgrowths from neighbouring vertebrae to form links or bridges of some size. It is of interest to note that the formation of exostoses is always more marked on the left in the lumbar region if the man is right-handed and vice versa. With advancing changes there is some degree of degeneration and thinning of the intervertebral discs, and this is a factor in the production of the osteophytes since it permits more play between the bodies and thus more strain on the ligaments in consequence of which hypertrophic changes occur as in other joints.

Exostoses may form in the interior of the spinal canal in relation to the posterior aspect of the vertebral bodies or may encroach upon the foramina by which the nerve roots emerge. In either case symptoms may arise due to pressure on the nervous structures. Some observers have detected sensory changes of minor degree in almost every case but severe symptoms are not common. Paraplegic effects have been described, but the most usual symptoms are backache and pain in the peripheral distribution of the nerves. Muscular wasting especially in the small muscles of the hands may be met with in osteoarthritis of the cervical spine, and brachial neuritis may be due to this cause. Occipital headache often attributed to fibrositis may be caused by osteoarthritis of the upper cervical vertebrae. In the dorsal region girdle pains are common, and other vague pains arising from this cause may give rise to suspicion of angina pectoris, gall-stones, or appendicitis; sciatic pains are not uncommon.

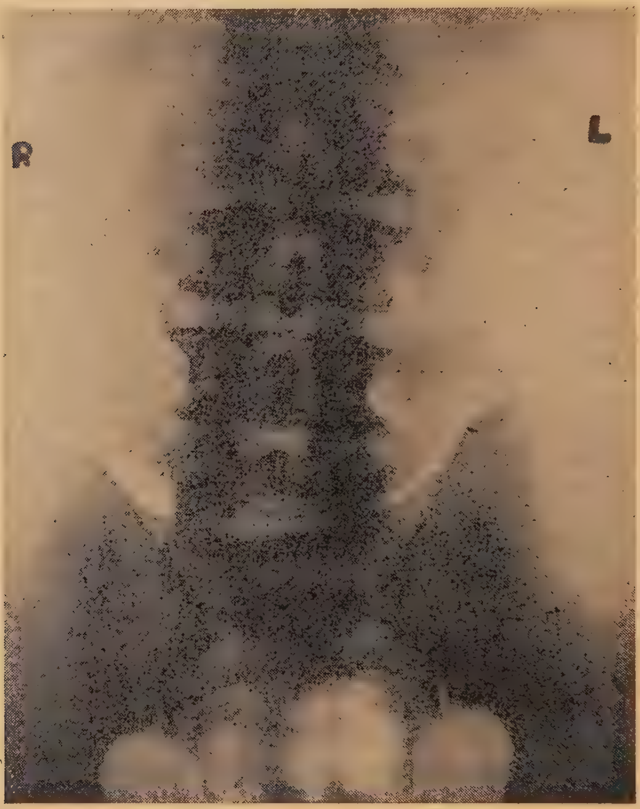

FIG. 30.—Spondylitis osteoarthritica showing osteophytes which tend to unite and form 'bridges' by synostosis

It is important to remember that the pressure may be most marked before ossification has taken place and be due to congestion and fibrositis. Radiography may thus show fully developed osteophytes on the opposite side to that on which the pain is felt, these not being in contact with the nerves while others in course of formation and not yet opaque to the rays may give rise to symptoms of nerve irritation.

Treatment will depend mainly on avoidance of the strains which brought about the condition. Radiant heat and massage will relieve pain and to some extent stiffness. Support by means of strapping will help in recent strains. Injection of lipiodol deeply into the muscles sometimes appears to be helpful, and aspirin will relieve pain; the use of methyl salicylate liniments will assist in this respect. Manipulation is apt to do more harm than good, and if attempted should preferably be carried out by an orthopaedic surgeon.

VI.—ARTHRITIS IN CHILDREN, OR STILL'S DISEASE

1.–DEFINITION

102.] In 1897 Still described a form of chronic polyarthritis of childhood with enlargement of the spleen and lymphatic glands as a constant feature.

2.–AETIOLOGY

Relation to infections

Nothing definite is known about the causation of this malady. In view of its similarity to rheumatoid arthritis in adults the probable importance of focal sepsis has been stressed. Infection of the tonsils, teeth, nasal sinuses or other site has been noted in many instances, but it is not constant nor does removal of such sepsis necessarily affect the progress of the patient. It is commonly accepted that the disorder is probably due either to various micro-organisms of low-grade virulence or to a specific infectious agent not yet isolated. French writers claim a tuberculous origin for Still's disease in some instances, but the generalized arthritis phase of certain types of tuberculous infections is usually fleeting. A form of hypertrophic pulmonary osteoarthropathy has also been described in association with a tuberculous focus, but in general it may be stated that positive tuberculin reactions in children with chronic arthritis are not more numerous than in healthy children of the same age. Syphilis plays no part in the origin of Still's disease, although possibly a rare type of osteoarthritis in childhood may be of spirochaetal origin.

Relation to rheumatic fever

The relation of Still's polyarthritis to acute rheumatic fever is not altogether clear. Subcutaneous nodules may occur in both, and heart disease occasionally complicates Still's polyarthritis. On the other hand the crippling joint-changes, the earlier age-incidence, the lymphatic hyperplasia, and recent work denying the presence of the Aschoff nodule—characteristic of acute rheumatic fever—all point to a separate disease process in Still's disease.

Endocrine theory

Endocrine disorders have been held to play a part in the malady, and recent work in France suggests that there may be a type of chronic arthritis in childhood with decalcification of the bones and a raised blood calcium due to disturbed parathyroid activity.

3.–MORBID ANATOMY

Joint-changes The joint-changes are not specific, and the histological picture is one of chronic inflammation with regressive, exudative, and proliferative changes resembling those of chronic rheumatoid (proliferative) arthritis in adults. The lesions mainly involve the synovial membranes, joint-capsule, and ligaments.

Long-standing cases In long-standing cases some bony changes—atrophy and erosion of the joint cartilage—may occur. The spleen and lymphatic glands show a simple hyperplasia.

4.–CLINICAL PICTURE

Onset The onset is usually acute, beginning in the first half of childhood but after the age of infancy. Fever, articular pain, swelling, and tenderness are usually present together from the start, but sometimes any one of these features may predominate so that pyrexia may lead later to the development of joint symptoms, or these latter may begin with an afebrile phase.

Symmetrical joint involvement The joints are usually involved symmetrically and most of the limb joints become involved more or less simultaneously. The spine and the sternoclavicular and the mandibular joints are sometimes also affected. Swelling, tenderness, and a curious puffy appearance without the presence of free fluid is found in the hands, feet, wrists, ankles, elbows, knees, shoulders, and hips, more or less in that order of incidence. Periarticular changes are present from the outset, and contractions soon appear. After a few weeks of fever the acute phase may pass, and the joints may progress slowly towards a more chronic state, but febrile episodes are common and with each bout the joints may get worse.

Anaemia A striking degree of anaemia is often present from the first, and when fever is present the lymphatic glands and spleen become involved. Glands may be felt in the groin, axilla, and, almost diagnostic of the disorder, in the epitrochlear regions. The blood shows a moderate leucocytosis as well as the secondary anaemia already mentioned. The sedimentation rate of the red blood corpuscles is usually increased during the febrile phases and is a useful guide as to the activity of the disease process.

Sweating is common, erythematous rashes of a fleeting character may occur, and subcutaneous nodules, as already mentioned, may occur over bony prominences as well as along tendons. Albuminuria is frequent during the acute phases, the tongue is usually coated, and there is a disinclination for food. *The heart* The heart is not usually involved more than would be expected with any infectious fever, i.e. its rate and size may be increased and there may be transient apical murmurs. Occasionally, however, conditions affecting muscle, valves, and pericardium may occur as in acute rheumatic fever. A persistent tachycardia during the afebrile period should lead to a suspicion of this. X-ray examination of the affected joints does not reveal anything characteristic. There may be some periarticular thickening with porosis of the bones adjacent to the joints.

5.–COURSE AND PROGNOSIS

The disease usually lasts for months, and sometimes for years, with febrile recurrences and progressive crippling. Death may be due to some intercurrent malady. On the other hand spontaneous arrest may occur at any time, irrespective of any special measures adopted in treatment, and although complete anatomical restitution is unusual, the functional activity of the joints may be restored to normal. No case should be regarded as hopeless, although the general outlook is usually poor.

6.–DIAGNOSIS

In the fully established case there is little difficulty in diagnosis. The spindle-shaped finger-joints, the enlargement of the spleen and of the epitrochlear and other lymphatic glands make a characteristic picture.

From acute leukaemia

It should be remembered that in acute leukaemia there may be pain and even swelling at the end of the long bones in the region of the large joints due to excessive activity in the marrow with invasion of the cancellous bone and, since the spleen and lymph glands are also involved in this malady, confusion may occur, easily settled by examination of the blood.

From other joint conditions

Certain forms of specific arthritis may be readily excluded such as gonococcal joint disease (both in the newly born and in later childhood), the joint-complications of haemophilia, the pseudo-arthritis of scurvy or of syphilitic bone disease in earlier life, and the rare occurrence of gout. For the most part these affect one joint only and have special features which make diagnosis relatively straightforward. The painless, symmetrical synovitis of the knees (Clutton's joints) in later childhood, due to congenital syphilitic infection, is unlikely to cause confusion. Multiple arthritis due to dysenteric infection is described; and since certain types of diarrhoea in infancy and early childhood are sometimes due to infection with micro-organisms of the dysentery group joint-involvement may follow. When this has occurred, however, it has mainly affected the large joints and the concurrent affection of lymphatic tissue is absent.

From Calvé's disease and Perthes's disease

The curious forms of osteochondritis occurring in later childhood in such situations as the spine (Calvé's disease) or the hip (Perthes's disease) have special localizations which mark them off from the generalized nature of Still's disease, and the same applies to acute monarticular arthritis or the subacute types associated with focal infection.

From acute juvenile rheumatism and non-specific polyarthritis

There remain for consideration under diagnosis the problem of acute juvenile rheumatism and certain rare types of chronic polyarthritis without involvement of the spleen and lymphatic glands. The points of resemblance between Still's disease and acute rheumatic fever have already been mentioned. In the latter there are usually only transient and minimal articular changes, fleeting swellings with pain and tenderness, but no periarticular changes or chronic progressive crippling such as occurs in Still's disease. Nor does the latter show the same dramatic response to salicylates as is seen in acute rheumatic fever as regards the arthritic and febrile manifestations.

From Jaccoud's chronic fibrous rheumatism

Among the rarer types of chronic polyarthritis in childhood may be mentioned the chronic fibrous rheumatism of Jaccoud with progressive stiffness of the joints due to fibrous changes more or less limited to the periarticular structures. The spleen and glands are not involved in this nor in yet another type of a rapidly crippling progressive form associated with marked trophic changes, extreme contractures, and eventual ankylosis, attended by advanced osteoporosis as shown in X-rays and a tendency to an increased blood calcium. Neither of these rarer forms is likely to be confused with the fully developed picture of Still's disease.

7.–TREATMENT

General nursing

Since the causation of Still's arthritis remains unknown, treatment can only be empirical and symptomatic. The acute onset means that the child must be confined to bed and splints, sand-bags, and cradles arranged to relieve the joint pains as much as possible. Salicylates are often given at this early stage and are usually disappointing although aspirin (10 grains three times a day for a child of five) is a useful sedative; and amidopyrine (pyramidon) in small doses (2 grains three times a day for child of five) is also useful, but the risk of agranulocytosis must be borne in mind. Attention must be paid to the bowels and skilful nursing may be necessary to secure adequate nourishment. To supply vitamins, diet should contain fresh fruit, plenty of milk, eggs, butter, and green vegetables. As soon as the first febrile stage is over the question of removing infected tonsils or diseased teeth must be carefully considered. Occasionally great benefit may be secured, although in general the results are disappointing. In any event bacteriological culture of any removed material should be carried out, and if possible a vaccine prepared. Intravenous injections of sodium salicylate or calcium acetylsalicylate and the organic arsenical preparations are favoured by certain Continental authorities in the early acute stages, and the internal administration of iodine, guaiacum, or calcium is also suggested.

To counteract anaemia

Blood transfusion and the use of big doses of iron are valuable measures to counteract the anaemia which so rapidly appears in many instances.

When the more chronic stage sets in, early orthopaedic advice should

The chronic stage

be obtained so that crippling deformities may as far as possible be prevented. Massage and movements often help considerably. General hygienic treatment as well as the regular physical measures available at a spa may help, and in certain instances children with Still's disease have greatly benefited from a visit to a Swiss clinic such as Leysin. Protein-shock therapy (by the use of milk, T.A.B. vaccine, or even autogenous vaccines) often produces a surprising degree of temporary improvement, especially as regards the functional activity of affected joints. Bee venom and the artificial production of fever by malarial infection have been recommended. Gold treatment is a new advance about which there is still some difference of opinion, especially regarding its value in children. A successful case of Still's disease treated by gold has been reported by Copeman, who used allochrysine (sodium aurothioproponal sulphonate) in a boy of twelve, giving four intramuscular injections of 0·05 gram at weekly intervals, followed after a break by three more injections of 0·01 gram.

Surgical

Radical surgical measures are not recommended, although some writers have reported improvement after splenectomy and, more recently, after parathyroidectomy when a raised blood calcium was present.

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ARTHROPODS AND DISEASE

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Reference may also be made to the following titles:

BITES AND STINGS
CHIGOE DISEASE
MYIASIS
SKIN DISEASES: AFFECTIONS DUE TO INSECTS AND ACARINES

103.] The demonstration in 1877 by Manson of the part played by the mosquito, *Culex fatigans*, in the transmission of *Wuchereria bancrofti* to man, and the discovery by Ronald Ross in 1897 of the part played by this mosquito in the transmission of the malaria parasite of sparrows, placed the relation of blood-sucking insects to the hosts on which they feed in an entirely new light. Insects, which had until then been regarded as pests only on account of the annoyance and trouble they caused, now became suspected of being transmitters of disease-causing organisms. When the parasite of human malaria, discovered by Laveran in 1880, was finally accepted as the causal organism of the disease, the study of blood parasites rapidly advanced, new forms were discovered, and each was now suspected of passing one phase of its existence in the body of a blood-sucking insect. The discovery by Smith and Kilbourne of the causal organism of Texas or red-water fever of cattle, and the demonstration that a tick, *Boophilus annulatus*, is its transmitter, further widened the field, so that blood-sucking arthropods other than insects were brought under suspicion as transmitters of disease-causing organisms.

The work of numerous investigators, many of whom have lost their lives while prosecuting their researches, has proved that arthropods play a most important part in the spread of human diseases.

Before outlining in detail why and how arthropods are important in human medicine it is necessary to define very briefly an arthropod, and to give a short summary of the subject.

Definition of arthropods

Briefly, an arthropod is an animal which has a hard outer skeleton and jointed limbs. Familiar examples are the crayfish, the lobster and the crab, and less familiar ones are scorpions, spiders, ticks, mites and the many thousands of insects such as beetles, butterflies, moths, flies, and fleas.

Although most of these animals are very unlike each other, for instance a lobster and a butterfly, nevertheless they are all built on the same common ground plan of structure mentioned above. Insects are, therefore, arthropods, but differ in one important respect from most of the others noted in that they possess only six legs.

It has been estimated that seven-eights of the protoplasm on the surface of the earth is contained within the hard skeleton of arthropods. They are one of the most dominant groups of animals and are to be found all over the world. Many have, in the process of time, become closely associated with man, and it is this association which has led to some passing their life histories in human tissues, others contaminating human food, and still others feeding on human blood. In this way they have come to be, either directly or indirectly, injurious to man.

As temporary parasites arthropods, and insects in particular, may be found living in human tissues, either as larvae (maggots) or as adults. The maggots of blow flies are well-known examples of the former, and the chigoe flea and itch mite of the latter. These examples further illustrate the fact that in the case of the maggots and the chigoe flea only part of the life history is passed in man's body, whereas in the case of the mite the entire life history is spent in the skin. In the case of two blow flies noted further on, their maggots can only complete their development in living tissues, so that the female fly lays its eggs in wounds and cuts, and never in decomposing animal matter. The chigoe flea and the mite can only complete their life histories in the skin either of man or of some animal. On the other hand some arthropods gain access to the human body only by accident, and they are as a rule found in the alimentary canal, having been ingested with food.

Then again there are many arthropods which, though not themselves producing disease, transmit pathogenic organisms during the act of feeding either on human food or on human blood. The house fly (*Musca* *domestica*) and its many tropical allies, in that they breed in faecal matter and are omnivorous feeders, readily transfer pathogenic intestinal organisms such as those of the typhoid group to human foodstuffs. Where sanitation is defective flies become numerous and diseases like typhoid, dysentery, and summer diarrhoea become epidemic. The great epidemic of typhoid in the Boer War is a good example.

Quite a number of mosquitoes subsist entirely on blood, and some of these prefer the blood of man to that of animals. In this way a mosquito (*Stegomyia fasciata*) has come to transmit the organism of yellow fever, which has long been endemic and often epidemic in West Africa and Central America. Many anopheline mosquitoes also prefer human blood to any other, and in the warmer regions of the earth commonly transmit the parasites of malaria. When very numerous, and the conditions for transmission are favourable, they cause great epidemics such as that which recently devastated parts of Ceylon, where it is said approximately 100,000 people died of malaria.

The tsetse flies also live only on blood and readily bite man, and so these flies, which are only found in tropical Africa, have come to transmit the pathogenic trypanosomes to man.

And lastly the body louse, a blood-sucking ectoparasite of man, is responsible for the transmission of the rickettsias of typhus and trench fevers, and the spirochaete of relapsing fever. Great epidemics of the two former have in the past swept over Europe and other regions, taking a very heavy toll of human life.

Following this short summary it is necessary to examine in a little more detail why, and how, arthropods are of importance in human medicine and to note the species concerned. Arthropods may either be themselves injurious, or they may be transmitters of disease-causing organisms as follows:

1. They may be themselves injurious:
    (a) by causing annoyance and discomfort by their presence;
    (b) by injecting irritating or poisonous fluids;
    (c) by living as temporary parasites in the skin.
2. They may be the transmitters of disease-causing organisms either mechanically or biologically.

1.–INJURIOUS ARTHROPODS

(a) Arthropods may be themselves injurious by causing annoyance and discomfort by their presence. Although there is no question here that any disease condition is produced, nevertheless it is worth remembering that arthropods (insects in particular) can, and do, cause much bodily discomfort and even mental distress, often leading to such conditions as insomnia. House flies, fleas, bugs and lice are good examples.

(b) Arthropods, by injecting irritating and poisonous fluids into the skin by their bites and stings, produce irritating and sometimes dangerous lesions. For an account of this aspect of the subject see the article Bites and Stings, p. 343.

(c) Arthropods may not only cause injury by living as temporary parasites in the tissues, but may also produce disease conditions. The most familiar example is the temporary invasion of the tissues by the larvae (maggots) of the higher flies (Diptera), producing the condition known as myiasis.

(1)—Myiasis-producing Flies

The flies whose larvae may thus be temporary parasites may be classified in three groups as follows:

Group I. Flies which lay their eggs or deposit their larvae on or near living tissues, or place the eggs on a special carrier.

Group II. Flies which, though normally breeding in decomposing animal or vegetable matter, also lay their eggs or deposit their larvae in human tissues, especially when diseased.

Group III. Flies which, though normally laying their eggs or depositing their larvae in decaying animal and vegetable matter and in excrement, will also breed in human foodstuffs.

Group I: (*a*) *Single Infestations*

Order Diptera; Family Muscidae. This group includes the following species, the larvae of which enter the unbroken skin or mucous membrane.

Warble fly of Africa

Cordylobia anthropophaga: the warble fly of Tropical Africa. Its larva is a parasite living in the skin of the rat, but has also been recorded as present in the skin of many other animals. Man commonly becomes infested accidentally. The female fly lays its eggs in the earth in burrows of rats, and the larva penetrates the skin when it comes in contact with the animal. It certainly does not lay its eggs on human clothing but may do so in the dust of a room where a rat or dog has been (and especially during the rainy season when the rat-burrows become flooded), and the larva may then accidentally come in contact with human clothes. Symptoms do not appear until the growth of the larva increases the size of the warble (the swelling it has produced) by causing an excessive serous exudate, and induces some pain. The larva leaves the skin in from nine to eighteen days and pupates in the ground. As a preventive measure rats should be trapped and driven out of houses and all infested specimens burnt. All servants and animals in the compound should be systematically examined for warbles. To remove the larva from the skin, Blacklock and Thompson recommend the application of liquid paraffin to the opening, first removing any scab; when the larva exhibits active movements and its body has been well lubricated with the oil, it can be expressed by pressure on each side of the warble with the thumb nails.

Warble fly of America

Dermatobia hominis: the warble fly of Tropical America. This fly is widely distributed in Central and South America. Its larva, known as 'ver macaque' in Cayenne, 'torcel' in Costa Rica, 'gusano moyocuil' in Mexico and 'berne' in Brazil, lives in the skin of all kinds of animals, especially cattle, producing a characteristic warble. The female lays her eggs in small packets on mosquitoes and haematophagous and sweat-feeding flies which visit man and animals. The larvae readily leave the eggs, rapidly penetrate the skin and disappear from sight. Dunn showed that clothing does not afford any protection. The warbles may be on any part of the skin, whether covered or uncovered; they are as a rule painful and last months if the larva is not removed. In localities where the fly is common a good mosquito curtain should be used during the night, and mosquito boots whenever there is a risk of being bitten by these insects. All larvae should be removed as soon as detected, as described in the case of *Cordylobia anthropophaga*.

Flesh flies

Wohlfahrtia vigil. This flesh fly is widely distributed in North America, especially in the east. It sometimes deposits a larva on the skin of children and a single boil-like warble is produced. Walker and others have recorded such cases from Toronto, Canada.

Wohlfahrtia magnifica. This species is widely distributed through Southern Russia, Asia Minor, Egypt, Syria, Iraq and Iran up to the north-west frontier of India. Although it commonly deposits its larvae in large numbers in cuts, wounds, abrasions of the skin and on the mucous membrane, especially the nasopharynx, in Egypt it occasionally deposits one or two larvae on the inner margin of the eye which produce the condition known as internal ophthalmomyiasis. The writer is indebted to one of his students, Dr. M. Tewfik Ismail, Government Ophthalmic Surgeon, for the following information:

Opthalmomyiasis is chiefly seen in children of the poorer classes during the summer when they are suffering from chronic conjunctivitis with a discharge. The odour from the pus-laden lids evidently attracts a female *W. magnifica* to deposit a larva on the middle canthus. The larva immediately penetrates the conjunctiva near the caruncle and buries itself in the orbital tissue. The child is usually brought to the hospital for excessive swelling of the eye, or perhaps because the mother has detected the posterior end of the larva. The eye should be carefully washed and a drop or two of dilute chloroform water should be run in where the end of the larva was noted; it will soon exhibit vigorous movements and, on protruding, the end should be grasped by sterilized fixation forceps. The wound usually heals rapidly.

The larvae of the bot and warble flies of animals are occasionally found in human tissues; the most common are the following:

Sheep nasal bot fly

Oestrus ovis: the sheep nasal bot fly. It normally deposits its larvae at the entrance of the nostrils of sheep and they ascend the nasal passages to come to rest in the nasopharynx. This fly occasionally deposits one or more larvae in the middle canthus of the human eye and the larva penetrates the conjunctiva and enters the orbital tissue, producing internal ophthalmomyiasis as in the case of *Wohlfahrtia magnifica.* The diagnosis and treatment are the same as for that fly. This condition is seen in Palestine and Asia Minor. In South America, in Central Asia and the Sahara, the larvae are found in the mucous membrane of the lids, producing the condition known as external ophthalmomyiasis.

Stomach bots of Equidae

Gasterophilus species: stomach bots of the Equidae. In certain parts of Russia the first stage larva of *Gasterophilus* has been recorded from the human skin. The condition is known as 'creeping disease', 'larva migrans' and 'Hautmaulwurf'. The larvae are usually those of either *G. nasalis* or *G. haemorrhoidalis*; they wander about in the skin causing some irritation.

Warble flies of cattle

Hypoderma species: the warble flies of cattle. Although normally laying their eggs on the hair of cattle these flies occasionally deposit them on the human hair or on human clothes, and the larva on hatching enters the skin, causing a small boil-like warble. They are usually painless.

GROUP I: (*b*) *Multiple Infestations*

Blow flies

Family Muscidae; Subfamily Calliphorinae: blow flies. The larvae of blow flies are very commonly found in human tissues of all kinds. The specific myiasis-producing species are the most important and at present only two of these are known.

Screw-worm flies

Chrysomyia bezziana: the Old World screw-worm fly. This species is widely distributed in the Ethiopian and Oriental regions extending to the Philippine Islands. It lays its eggs only in living tissues such as cuts or wounds, and on diseased and damaged mucous membranes.

Nasopharyngeal myiasis (known as 'Peenash' in India) is common, the larvae often causing extensive destruction of tissue. When fully grown the larvae crawl out and pupate in the ground. The flies are usually more numerous after the rains.

Chrysomyia (*Cochliomyia*) *americana*: the New World screw-worm fly. This species was discovered by Cushing in the writer's laboratory in October 1933, its true identity having been obscured by its close similarity to *C. macellaria*, from which it can only be distinguished with certainty on the characters of the terminalia. It is widely distributed in North, Central and South America. Its life history and habits are similar to those of *C. bezziana*.

GROUP II

Order Diptera; Family Muscidae (several subfamilies and genera). These flies are not primary myiasis-producing species but normally lay their eggs or deposit their larvae in decaying animal matter; they often lay their eggs or deposit their larvae in diseased tissues. The following are the most important species:

Chrysomyia (*Cochliomyia*) *macellaria*. This species is confined to the New World; it commonly lays its eggs in diseased tissues.

Other species are *Phormia regina*, the black blow fly; *Lucilia sericata*, the sheep maggot fly; *Musca domestica*, the house fly; and *Fannia scalaris*.

Many species of flesh flies, *Sarcophaga*, deposit their larvae in diseased human tissues.

GROUP III

Order Diptera; Family Muscidae (many subfamilies and genera). The flies of this group are accidental myiasis-producers. They normally lay their eggs or deposit their larvae in decaying vegetation or excrement, but sometimes introduce them into human foodstuffs when stale or decaying. In this way their larvae enter the alimentary tract and the urinary bladder. The following are the most important species:

Sarcophaga haemorrhoidalis, *S. hirtipes* and *S. fuscicauda* (intestinal myiasis); *Musca domestica* (intestinal and urinary myiasis); *Muscina stabulans*, *Fannia canicularis* and *F. scalaris*, *Syrphus* species, *Eristalis tenax* and others, *Apiochaeta scalaris* and *Teichomyza fusca* (all intestinal myiasis).

(2)—Fleas

Chigoe

Order Siphonaptera: fleas. By the term tungiasis is understood the invasion of the human skin by the adult female chigoe flea *Tunga penetrans* (Jigger, Nique or Pique; see article CHIGOE DISEASE).

(3)—Beetles

Scarabiasis

Order Coleoptera: beetles. By the term scarabiasis is understood the temporary invasion of the intestine of children by certain dung beetles (*Onthophagus bifasciatus*, *O. unifasciatus* and *Caccobius mutans*). This condition is not uncommon in Ceylon in children from three to eight years of age and is known as 'kurimini manama' or 'beetle disease'. The infested child suffers from abdominal pain, after which many beetles may be passed in the faeces. The condition is also recorded from many parts of Bengal. An enema given twice daily will soon clear the large intestine of the beetles. Children should not be left about naked, especially if the anal opening is soiled.

(4)—Itch Mite

Scabies

Class Arachnida; Order Acarina; Suborder Sarcoptoidea; Family Sarcoptidae: scabies, the invasion of the human skin by the mite *Sarcoptes scabiei.* For further information on this subject see the article entitled SKIN DISEASES: AFFECTIONS DUE TO INSECTS AND ACARINES.

(5)—Tongue Worms

Tongue worms

Class Pentastomida; Order Linguatoidea; Family Linguatulidae. Porocephaliasis is a somewhat loose term used for a doubtful morbid condition in man said to be due to the invasion of the organs, particularly the liver, by the early stages of tongue worms, particularly *Armillifer armillatus* and *Liguatula serrata* in West Africa. It is impossible to diagnose the condition during life, and the encysted early stages of these remarkable parasitic arthropods are as a rule only found post mortem in the lung, liver and spleen.

2.–ARTHROPODS AS TRANSMITTERS OF DISEASE

(1)—Mechanical Transmitters

The term mechanical transmitter here connotes arthropods which either (*a*) carry pathogenic organisms on their bodies and appendages and deposit them on man's body or food, or (*b*) ingest such organisms, which multiply in the alimentary tract and are then transmitted either by regurgitation or in the faeces. It is very difficult to decide with certainty whether in some of these cases the arthropod is a mechanical or a biological transmitter, especially in the case of leishmania parasites and the rickettsias of the various forms of typhus. In the first case it is still doubtful whether the sandfly (or in fact any arthropod) is the true host of the leishmania parasites, although it is fairly generally held to be so. It is also still doubtful if in the case of the rickettsias the mechanism of transmission is purely mechanical. They will both, however, be treated here as examples of biological transmission.

The arthropods will be dealt with as follows: Order Diptera, the flies, Order Siphonaptera, the fleas.

Yaws

Order Diptera; Family Muscidae; Subfamily Oscininae; Genera *Hippelates* and *Siphunculina*: eye flies. Diseases of the skin, yaws. In 1912 Nicholls suggested that one of the eye flies—*Hippelates pallipes*—of the West Indies was the most probable transmitter of the causal organism of yaws. Kumm (1935), who recently carried out some exact experiments with *H. pallipes* and yaws in Jamaica, has reached the following conclusions. Motile spirochaetes are present in the vomit and faecal drops of eye flies that have fed on yaws sores which are moist and devoid of scabs; ingested spirochaetes remained motile in the crop of the fly for about seven hours, but those in the stomach and proboscis soon lost their motility; the number of spirochaetes rapidly diminishes after the first day and none are seen after the second day. The eye fly may, therefore, transmit *Treponema pertenue* by its vomit drop during the first eight hours after ingesting the organism.

Conjunctivitis

Subfamily Muscinae; Genus *Musca*. Diseases of the eye. There is no doubt that flies frequenting the human body, especially species of *Musca*, eye flies and others, mechanically transmit such organisms as the Koch-Weeks bacillus of acute contagious conjunctivitis and the Morax-Axenfeld bacillus of subacute or angular conjunctivitis.

Intestinal diseases

Intestinal diseases. The house fly *Musca domestica*, its tropical allies (*M. vicina*, *M. nebulo*, and *M. sorbens*), and some of the blow flies (Genera *Calliphora*, *Lucilia*), transmit pathogenic intestinal bacteria and protozoa mechanically by the vomit drop, by contaminated legs and bodies and by the faeces, to human food and the human body.

Bubonic plague

Order Siphonaptera: fleas. Bubonic plague. In the case of bubonic plague *Pasteurella pestis* is transmitted mechanically to man by the regurgitation of the haemobacillary plug when a blocked or partially blocked flea bites man. It has been shown by Hirst that the double bite method of a blocked flea is a common way in which the organism is transmitted to man. Although *Xenopsylla cheopis* is the most important transmitter, many other fleas also become blocked and are capable of transmitting *Pasteurella pestis* to man.

(2)—Biological Transmitters

By the term biological transmission is here understood cases in which a pathogenic organism, after entering the alimentary tract of the transmitting arthropod, passes out of it to the salivary glands, and is transmitted when the saliva is injected into the skin; or it may after passing out of the alimentary tract into the haemocoele remain there, or infect the eggs in the ovary; or it may pass to the muscles of the thorax as in the case of many Filaridae, and, after further development eventually reach the labella and be transmitted when the arthropod bites. In all these cases a considerable interval elapses between the ingestion of the causal organism (infected arthropod) and its transmission (infective arthropod). This method of transmission is also spoken of as the cyclical. There is not, however, any hard and fast line of demarcation between true mechanical and true biological transmission. In the case of the latter it is believed that the arthropod is essential in the extra-corporeal life of the organism and that it cannot be transmitted except by the arthropod. In the case of the parasites of malaria the anopheline mosquitoes are the true hosts of these organisms. It is uncertain if the rickettsias can be transmitted in any other way than by an arthropod. There is no doubt that the arthropod host is a true biological transmitter of the viruses of yellow fever and dengue.

As in the case of the mechanical transmitters, the biological ones are dealt with under their respective orders as follows: (i) Class Hexapoda: insects; (*a*) Order Diptera: flies. (*b*) Order Siphonaptera: fleas. (*c*) Order Anoplura, Suborder Siphunculata: sucking lice. (ii) Class Arachnida: spiders, scorpions, ticks and mites.

(*a*) *Flies* (*Diptera*)

Filariasis

Order Diptera; Suborder Orthorrhapha, the lower Diptera; Section Nematocera, with long antennae; Family Chironomidae, Midges; Subfamily Ceratopogoninae; Genus *Culicoides*: the blood-sucking midges, punkies, no-see-ums. Filariasis. Two species of *Culicoides* transmit pathogenic Filaridae to man. *C. grahami*, as shown by Sharpe, transmits *Dipetalonema perstans* to man in West Africa. *C. furens*, which is widely distributed in the West Indies, has been shown by Buckley to transmit *Mansonella ozzardi* to man.

Family Simuliidae; Genus *Simulium*: turkey gnats, buffalo gnats, black flies. These small black hunchbacked flies are well-known pests. Blacklock showed that *S. damnosum*, the Jinji fly, is the transmitter of *Onchocerca volvulus* to man in Africa. Gibbins stated that *S. neavei* is a probable transmitter of *O. volvulus* in the Belgian Congo and Kenya.

Strong and his colleagues recently showed that in Central America (Guatemala) the blinding filaria *O. caecutiens* is transmitted to man by *S. avidum, S. ochraceum* and *S. mooseri.*

Family Psychodidae; Subfamily Phlebotominae; Genus *Phlebotomus*: sandflies. Leishmaniasis and Oriental sore. The brothers Sergent and co-workers produced a typical Oriental sore by crushing seven specimens of *P. papatasii* on the skin, thus showing that *Leishmania tropica* is transmitted by this sandfly. Adler stated that *P. sergenti* was the transmitter in Baghdad. *P. intermedius* and *P. lutzi* are suspected as being the transmitters of espundia, the local form of South American leishmaniasis. Since Knowles, Napier and Smith in 1925 first described the development of the parasite of kala azar in *P. argentipes* it has been shown that the flagellates swim forward and collect at the end of the pharynx. It was assumed that having reached this position they were ready to be transmitted by the bite, but so far, except in the case of a single hamster, all feeding experiments on this animal, and also on man, have failed. Thus it does not appear to be proved that *L. donovani* is transmitted by the bite of infected sandflies. In China *P. chinensis*

Leishmaniasis

Espundia

Kala azar

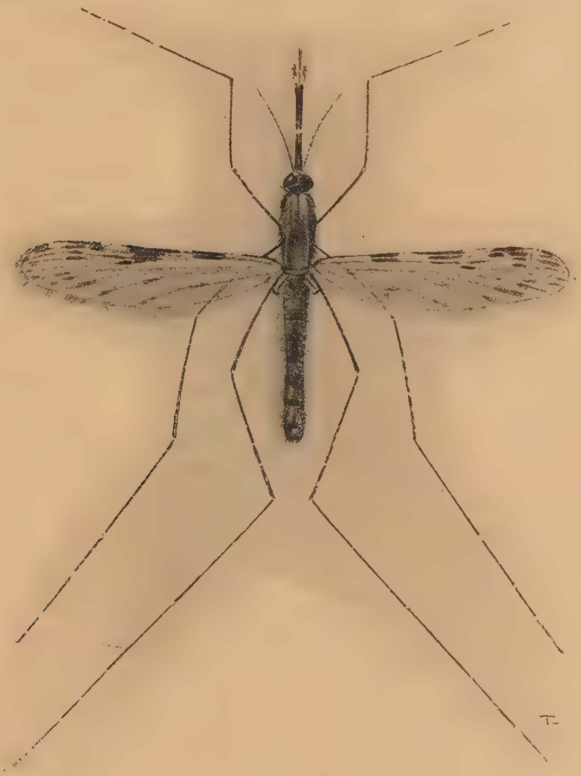

FIG. 31.—♀ *Anopheles costalis* (*gambiae*), the transmitter of the parasites of malaria in Africa (Patton and Cragg, *Textbook of Medical Entomology*, 1913)

is a suspected transmitter, and in the Mediterranean region *P. perniciosus*.

Papataci fever

The filter-passing virus of papataci or phlebotomus fever is transmitted by *P. papatasii*, the sandfly becoming infective seven to ten days after feeding on the blood of a patient during the first day of the disease.

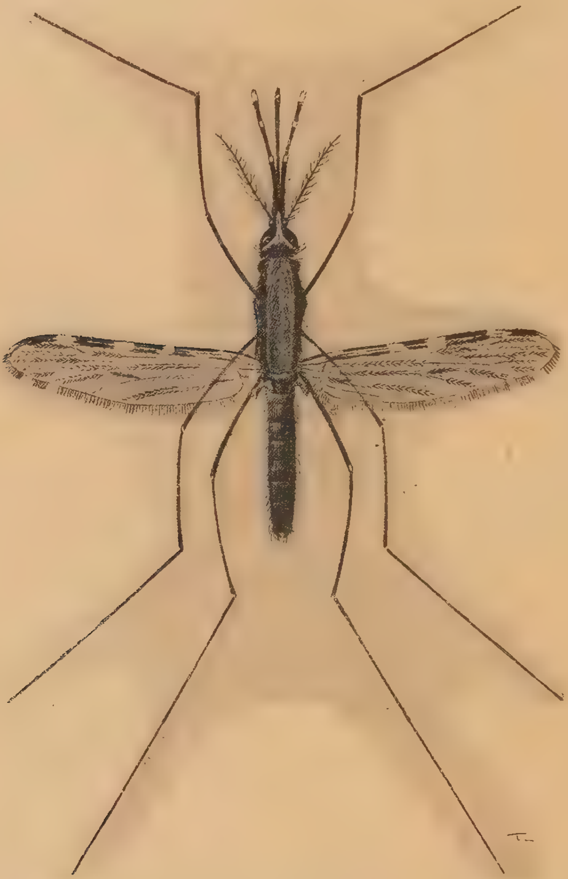

FIG. 32.—♀ *Anopheles culicifacies*, the transmitter of the parasites of malaria in the East; this mosquito was the cause of the recent outbreak of malaria in Ceylon where about 100,000 people lost their lives. (Patton and Evans, *Insects, Ticks, Mites and Venomous Animals of Medical and Veterinary Importance*, Part I, 1929)

Carrion's disease

The causal organism of verruca peruviana (Carrion's disease) in the Peruvian Andes is most probably transmitted by *Phlebotomus verrucarum* and *P. noguchi* as suggested by Townsend and shown by Noguchi, Shannon and their co-workers.

Family Culicidae; Subfamily Culicinae; Tribe Anophelini. Mosquitoes are the proved transmitters of the causal organisms of malaria, yellow fever, dengue fever and some forms of filariasis.

Malaria

Malaria. The following is an alphabetical list of the species of *Ano-*

pheles in which the infectivity rate is always high, and which are transmitters of the first importance throughout most of their range of distribution; in all the species there are records of infection both natural and experimental.

Anopheles albimanus, distribution Central and South America and Antilles, including Barbados; *A. albitarsis*, South America; *A. costalis* (*gambiae*), Ethiopian region, Arabia in the Aden Hinterland; *A. culicifacies*, India and Ceylon; *A. darlingi*, Brazil, Venezuela; *A. elutus*, Mediterranean region, Iraq (lower), Transcaspia; *A. fluviatilis*, India, Siam, Tonkin, Turkestan; *A. funestus*, Ethiopian region; *A. jeyporiensis* (*candidensis*), Formosa, China, Tonkin, Burma and India; *A. maculatus*, Oriental region (hilly tracts); *A. maculipennis* var. *atroparvus*, Coastal districts of Europe, especially northern; *A. maculipennis* var. *labranchiae*, Italian littoral, Italian islands, littoral of South Spain and North Africa, dominating species in Roman Campagna; *A. minimus*, North-East India, Oriental region (Philippine Islands); *A. pattoni*, North and Central China; *A. punctulatus*, New Guinea (North Coast); *A. punctulatus* var. *moluccensis*, Western New Guinea; *A. quadrimaculatus*, Western North America; *A. sinensis* (*hyrcanus*), India, Malay,

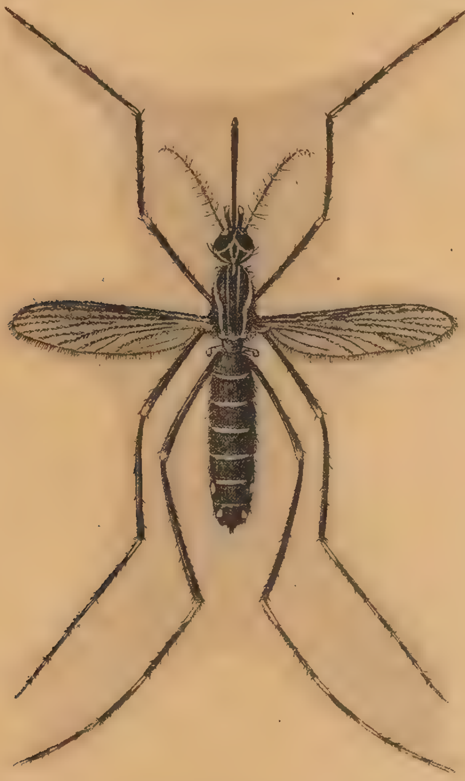

FIG. 33.—♀ *Aëdes* (*Stegomyia*) *fasciata*, the transmitter of yellow fever (Patton and Cragg, *Textbook of Medical Entomology*, 1913)

Indo-China, China; *A. stephensi*, India; *A. sundiacus*, Oriental region; *A. superpictus*, Mediterranean region to North-West India; *A. tarsimaculatus*, Central and South America, Lesser Antilles, Trinidad; and *A. varuna*, Eastern Peninsula of India.

Yellow fever

The Culicine Mosquitoes; Tribe Culicini. Yellow Fever. *Aëdes* (*Stegomyia*) *fasciata* (*aegypti*) is still the only proved transmitter of the virus of yellow fever to man. Stokes, Bauer and Hudson from a fresh investigation of the yellow fever problem in West Africa reached the following conclusions: Mosquitoes can only pick up the infection from man during the first three days of the disease, but they can transmit this infection by bites on the day after it has been absorbed, and retain this power for the remainder of life. In Southern Nigeria Beeuwekes and his co-workers found that the average length of life of the female *S. fasciata* was from 70 to 225 days. Recent experiments on monkeys by Bauer and his co-workers in West Africa, and by Shannon and Davis in South America, proved that a number of other Culicines are potential transmitters, as follows.

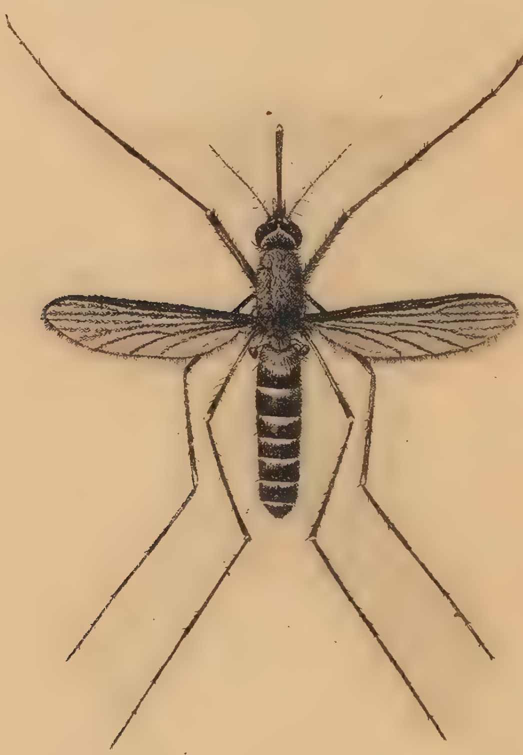

FIG. 34.—♀ *Culex fatigans*, the transmitter of *Wuchereria bancrofti* (Patton and Cragg, *Textbook of Medical Entomology*, 1913)

Experimental transmitters. Species shown by transmission experiments to be capable of infecting by the bite. West African Species:

Aëdes (*Stegomyia*) *luteocephalus*, *A. africanus*, *A. simpsoni* and *A. vittatus*, *Aëdes* (*Aëdimorphus*) *stokesi*, *Eretmopodites chrysogaster*, *Mansonia* (*Mansonioides*) *africana* and *Culex thallasius*. South American Species: *Aëdes fluviatilis* and *A. scapularis*.

Species non-lethal to the virus. They are capable of retaining the virus throughout their lives but cannot transmit by their bite. West African Species: *Aëdes* (*Aedimorphus*) *irritans*, *A. nigricephalus*, *Aëdes* (*Banksinella*) *punctocostalis*, *A.* (*Banksinella*) *lineatopennis* and *Mansonia* (*Mansonioides*) *uniformis*. South American Species: *Aëdes serratus*, *A. taeniorhynchus*, *A. terrens*, *Mansonia albicosta*, *M. chrysonotum*, *M. fasciolata*, *Psorophora cingulata* and *P. ferox*.

Dengue

Dengue Fever. The recent work of Silar and his co-workers, and that of Simmons and his associates, has proved that *Stegomyia fasciata* and *S. albopicta* are efficient transmitters of the virus of dengue fever. *Armigeres obturans* is suspected of being a transmitter in Formosa.

Filariasis (*Wuchereria bancrofti*)

Filariasis. The following is a list of the more important mosquitoes which are efficient transmitters of *Wuchereria bancrofti* to man:

Culex fatigans, distribution Oriental, Ethiopian and Australasian regions, Tropical and Subtropical America; *Aëdes* (*Stegomyia*) *variegatus* (*pseudoscutellaris*) and races, Pacific Islands; *Culex pipiens* var. *pallens*, *C. tipuliformis*, *C. tritaeniorhynchus*, *C. sinensis* and *C. whitmorei*, *Aëdes* (*Finlaya*) *togoi*, *Anopheles sinensis*, Japan, Formosa, China; *Taeniorhynchus* (*Mansonioides*) *africanus*, Ethiopian region (doubtfully in Australasia); *T.* (*Mansonioides*) *uniformis*, Oriental, Ethiopian and Australasian regions; *Anopheles rossi*, Oriental region; *A. costalis*, Ethiopian region, and *A. algeriensis*, Palaearctic region.

The non-periodic variety of *Wuchereria bancrofti* is transmitted by *Aëdes* (*Stegomyia*) *variegatus* in Polynesia. There are a number of species of mosquitoes in which only partial development takes place. *Culex fatigans* is the only known transmitter of *W. malayi*.

Loa loa and tularaemia

Section Brachycera, the lower Diptera with shorter antennae; Family Tabanidae: gad-flies, etc.; Subfamily Pangoninae; Genus *Chrysops*: deer flies, etc. *C. silacea* (and probably *C. dimidiata*) have been shown by the Connals to be the transmitter of Loa loa in West Africa. *C. discalis* has been shown by Francis and Mayne to be one of the transmitters of *Bacterium tularense*, the causal organism of tularaemia. It is not known whether this transmission is mechanical or biological.

Sleeping sickness

Suborder Cyclorrhapha, the Higher Diptera; Family Muscidae; Subfamily Glossininae; tsetse flies. The form of human trypanosomiasis which is usually attributed to *Trypanosoma gambiense* is transmitted cyclically to man by *Glossina palpalis*. The Rhodesian form of the disease, which is attributed to *T. rhodesiense*, is transmitted by *G. morsitans*. In the Gold Coast the human trypanosome is transmitted by *G. tachinoides*. It should be remembered, as pointed out by Duke and others, that these human trypanosomes are sometimes transmitted mechanically by *G. palpalis* and probably by *G. morsitans* and *G. tachinoides*.

(*b*) *Fleas* (*Siphonaptera*)

Endemic typhus

Order Siphonaptera: fleas. Endemic typhus (shop typhus; grain store typhus). It has long been known that a mild sporadic form of typhus is not uncommon in summer and autumn in America among well-to-do people. Dyer and his colleagues have shown that the virus is acquired by the rat-flea *Xenopsylla cheopis* from infected rats, and is then transmitted to man by the faeces of the fleas (not by the bite). Once a flea becomes infected it remains infective for the rest of its life, which may be many months. *Ceratophyllus fasciatus* can also transmit the virus from rat to rat.

(*c*) *Lice and Bugs*

Order Anoplura: lice; Suborder Siphunculata: Sucking lice. Family

Endemic typhus

Pediculidae; Genus *Pediculus*. Endemic typhus. *Rickettsia prowazeki*, as is well known, is transmitted from man to man by the body louse *Pediculus humanus corporis*. The infection may be acquired by the bite of the louse, by crushing infective lice on the skin or by faeces of infective lice. Once a louse is infected it remains infective for the rest of its

Relapsing fever

life. The *Treponema recurrentis* of relapsing fever is transmitted to man when an infected louse is crushed on the skin. The *Rickettsia quintana*

Trench fever

of trench fever is transmitted to man by the excreta of an infected louse.

Cone nose bugs

Order Hemiptera; Family Reduviidae: cone nose bugs; Genus *Triatoma*. *T. megista* is the common transmitter of *Trypanosoma cruzi* to man, the infection being acquired from the faeces of the bug and not from the bite; there are several other species such as *Rhodnius prolixus* which can also transmit the parasite.

Bed-bugs

Family Cimicidae. Although the bed-bugs, *Cimex lectularius* and *C. hemiptera* are common blood-suckers, they have not been proved to be transmitters of any pathogenic organisms.

(*d*) *Ticks and Mites* (*Arachnida*): *Crustacea*

Class Arachnida; Order Acarina; Suborder Mesostigmata: ticks and mites; Family Argasidae: soft bodied ticks; Genus *Ornithodoros*.

Relapsing fever

Relapsing Fever. *O. moubata* the blind tampan, which is widely distributed in Tropical Africa, is the transmitter of *Treponema duttoni* to man; in Dakar, according to Mathis, the transmitter is *O. morocanus*. The strain *Treponema persicum* occurring in Persia and North West India is transmitted by *Ornithodoros tholozani* and *O. lahorensis*; the Spanish strain is transmitted by *O. morocanus* and the South and Central American strain (*S. venezuelensis*) by *O. venezuelensis* and *O. talaje*.

Family Ixodidae: Hard bodied ticks; Genera *Dermacentor*, *Amblyomma*, *Haemaphysalis*, etc. Rickettsiasis.

Rocky Mountain spotted fever

Rocky Mountain spotted fever: North American form of endemic typhus. It is now known that this form of typhus is much more widely distributed in North America. On the western side (Northern Rocky Mountain States and eastern slope of the Cascades) the wood tick, *Dermacentor venustus* (*andersoni*), is the transmitter of *Rickettsia ricketsii*. On the eastern side, on the other hand, it is transmitted by the American dog tick *Dermacentor variabilis*. In both cases it is the adult which attacks man, the larva and nymph *D. venustus* usually feeding on ground and pine squirrels. A single infective adult will transmit the organism, but the tick must feed for from two to ten hours before the transmission can take place. All ticks should therefore be removed as soon as possible after they have become attached.

Endemic typhus

In Brazil and probably in other States of South America a similar form of endemic typhus which is said to be caused by *Rickettsia braziliensis* is transmitted by *Amblyomma cajennense* and *A. ovale*. Endemic typhus of Europe, or *fièvre boutonneuse*, caused by *Rickettsia conori*, is transmitted to man by the bite of the dog tick, *Rhipicephalus sanguineus*, the dog being the reservoir. The rickettsia of the endemic typhus of Kenya and South Africa is probably also transmitted by the dog tick *R. sanguineus*.

Tick paralysis

Tick paralysis is a pathological condition which follows the bites of certain ticks. In North America *Dermacentor venustus* and *Haemaphysalis cinnabarina* have been incriminated. In South Africa it follows the bite of *Ixodes pilosus*, and in Australia the bite of *I. holocyclus*.

Tularaemia

Tularaemia. It is known that *Dermacentor venustus* can transmit *Bacterium tularense* to man, having acquired the causal organism from a rodent.

Suborder Heterostigmata; Family Trombidiidae: velvet or plush mites; Genera *Trombidium*, *Trombicula*, etc. Rickettsiasis.

Japanese river fever

Japanese river fever: Endemic mite typhus of Japan. This disease is common in many parts of Japan; it is said also to occur in Cochin China, and probably in Malaya and Sumatra. The causal organism, *Rickettsia orientalis*, is transmitted by the larval mite *Trombicula akamushi*, the infection having been acquired from the mole *Microtus montbelloi*.

Endemic mite typhus of Malay, Sumatra (and probably Australasian region), scrub (K form) typhus. The causal organism of this form of the disease is probably also *R. orientalis*. It is transmitted by *Trombicula deliensis*, a species widely distributed in the area. Rats are reservoirs of the organism.

Class Crustacea; Subclass Copepoda; Order Eucopepoda; Genera *Cyclops* and *Diaptomus*: water fleas.

Dracontiasis

Dracontiasis. Species of *Cyclops* (*C. coronatus*, *C. bicuspidatus* and *C. quadricornis*) are intermediary hosts of *Dracunculus medinensis*. The larval Guinea worm passes to the haemocele of the *Cyclops*, and is liberated when the *Cyclops* is swallowed in drinking water.

Tapeworms

Diphyllobothriasis. Species of *Cyclops* and *Diaptomus* (*C. brevispinosus*, *C. prasinus*, *C. strenusus*, *D. oregonensis*) are the first intermediate hosts of the tapeworm *Diphyllobothrium latum* which undergoes its procercoid stage in the haemocele. Species of fish (pike, turbot, pickerel) are the second intermediate hosts.

Paragonimiasis

Order Decapoda: Crayfish and Crabs. Paragonimiasis. Species of crayfish (*Astacus japonicus*, *A. similis*) and crabs (*Potamon dehaarni* and *P. obtusipes*) are the second invertebrate hosts of *Paragonimus westermani.*

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ARTIFICIAL RESPIRATION

See DROWNING: RESUSCITATION; *and* RESUSCITATION

ASBESTOSIS

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Reference may also be made to the following titles:
ANTHRACOSIS PNEUMOCONIOSIS SILICOSIS

1.–DEFINITION

104.] Asbestosis is an occupational pneumoconiosis caused by the inhalation of asbestos dust.

Asbestos is the commercial name given to two groups (with their subdivisions) of fibrous, heat- and acid-proof minerals—namely, actinolite and chrysotile. Chemically they are hydrated magnesium silicates containing varying amounts of lime, alumina, iron or manganese, the composition differing with locality. This 'physical paradox', or 'mineralogical vegetable' as it has been termed, can be carded, spun and woven as readily as wool, flax or silk.

Asbestos is of importance in medicine on account of the rapid expansion of the industry during the past twenty years, and of interest because asbestos dust—a silicate dust—has been proved to cause pulmonary fibrosis. Until recent years silica was looked upon as the only mineral responsible for respiratory disability, and silicate dust of whatever composition was regarded as non-injurious. That contention may still be true because asbestos, in addition to its unique physical properties, has unusual chemical characteristics. Weak acids, such as acetic, dissolve the bases magnesium and calcium, leaving pure silica without destroying the appearance and flexibility of the fibre. This same change is probably brought about by tissue juices in the lungs thus releasing free silica which acts as the fibrosing agent. Support for this view is supplied by the fact that analysis shows the presence of free silica both in the asbestosis bodies and in the lung (see p. 141).

The processes of manufacture have been divided into two groups according to the amount of dust generated. The 'less dusty' operations are spinning, twisting and plaiting, and the 'more dusty' milling, mixing, carding, weaving and mattress-making. Samples taken by Owen's apparatus show that 90 per cent of the dust particles measured 7·5μ or less, and 80 per cent, 2μ or less. Long fibres 100μ or more in length, and large black, blue and yellow fragments of asbestos are also found. As asbestos fibres owing to their brittleness may split longitudinally beyond the limits of direct microscopical measurement, it may be assumed that the dust contains many ultra-microscopic particles.

2.–AETIOLOGY

Incidence

As would be expected, the disease is more common among those engaged in the 'more dusty' processes. Merewether gave the following results of the examination of 500 workers in the 'less dusty' and of 845 in the 'more dusty' processes.

TABLE I.—Incidence Rates of Definite Fibrosis (Asbestosis) in Workers in the 'Less Dusty' and 'More Dusty' Processes

	Incidence Rates of Asbestosis per Cent			
	0-4 Years Employed	5-9 Years Employed	10-19 Years Employed	20 Years and over Employed
Less dusty processes	0	2·4	8·3	5·0
More dusty processes – –	0·7	2·1	19·0	40·6

The shortest period of exposure to asbestos dust that resulted in death from advanced fibrosis was 4·4 years, and the average exposure in the twenty-seven fatal cases of pure asbestosis in England up to 1933 was 13·3 years.

Relation to tuberculosis

That there is an increased liability to tuberculosis appears to be very definite. The risk cannot be estimated from the small number of cases recorded at present and the incidence rate will have to be amended as further statistics become available.

TABLE II.—Forty-two Fatal Cases of Asbestosis and Asbestosis with Tuberculosis

Disease	Number of Deaths	Age at Death			Duration of Exposure in Years			Period between last Exposure and Death		
		Highest	Lowest	Average	Longest	Shortest	Average	Longest	Shortest	Average
Asbestosis –	27	63	26	40·8	27	4·4	13·3	14·3	2 days	2·96
Asbestosis with tuberculosis	15	67	22	41·6	24	2·6	11·3	12·2	0·3	4·6

Of the forty-two fatal cases, fifteen (35·7 per cent) were complicated by tuberculosis. Asbestosis is comparable, in the duration of exposure and average age at death, with the acute forms of silicosis seen in sand-blasters and those employed in the manufacture of scouring powders. Merewether gave the following interesting comparisons:

TABLE III.—Comparisons between all Forms of Silicosis, Asbestosis and Acute Silicosis

Disease	Number of Deaths	Average Age at Death	Duration of Exposure in Years		
			Longest	Shortest	Average
Silicosis (all forms)	311	55·8	62·0	2·3	35·1
Silicosis with tuberculosis	391	52·4	67·0	2·0	31·7
Asbestosis –	52	41·9	27·0	1·5	12·4
Asbestosis with tuberculosis	30	37·1	29·0	0·8	9·5
Silicosis (acute) –	10	38·8	13·5	4·8	9·0
Silicosis (acute) with tuberculosis	18	38·8	15·2	2·2	7·3

3.–MORBID ANATOMY

Fibrosis of lungs and adhesions

The salient features in the gross morbid anatomy are dense pleural adhesions, which may obliterate the pleural sacs. The bases of the lungs are firmly adherent to the diaphragm. There is a widespread pulmonary fibrosis affecting especially the lower lobes. As the result of fibrosis and pleural adhesions, bronchiectasis develops and may go on to abscess formation. The circumscribed fibrotic nodules characteristic of silicosis are rarely found in asbestosis. On section the fibrosed portions present a greyish-black mottling, dense, airless patches merging into areas less affected. The whole of the lungs are firmer than normally.

Histology

Histologically the lesion is a chronic interstitial fibrosis. In the early

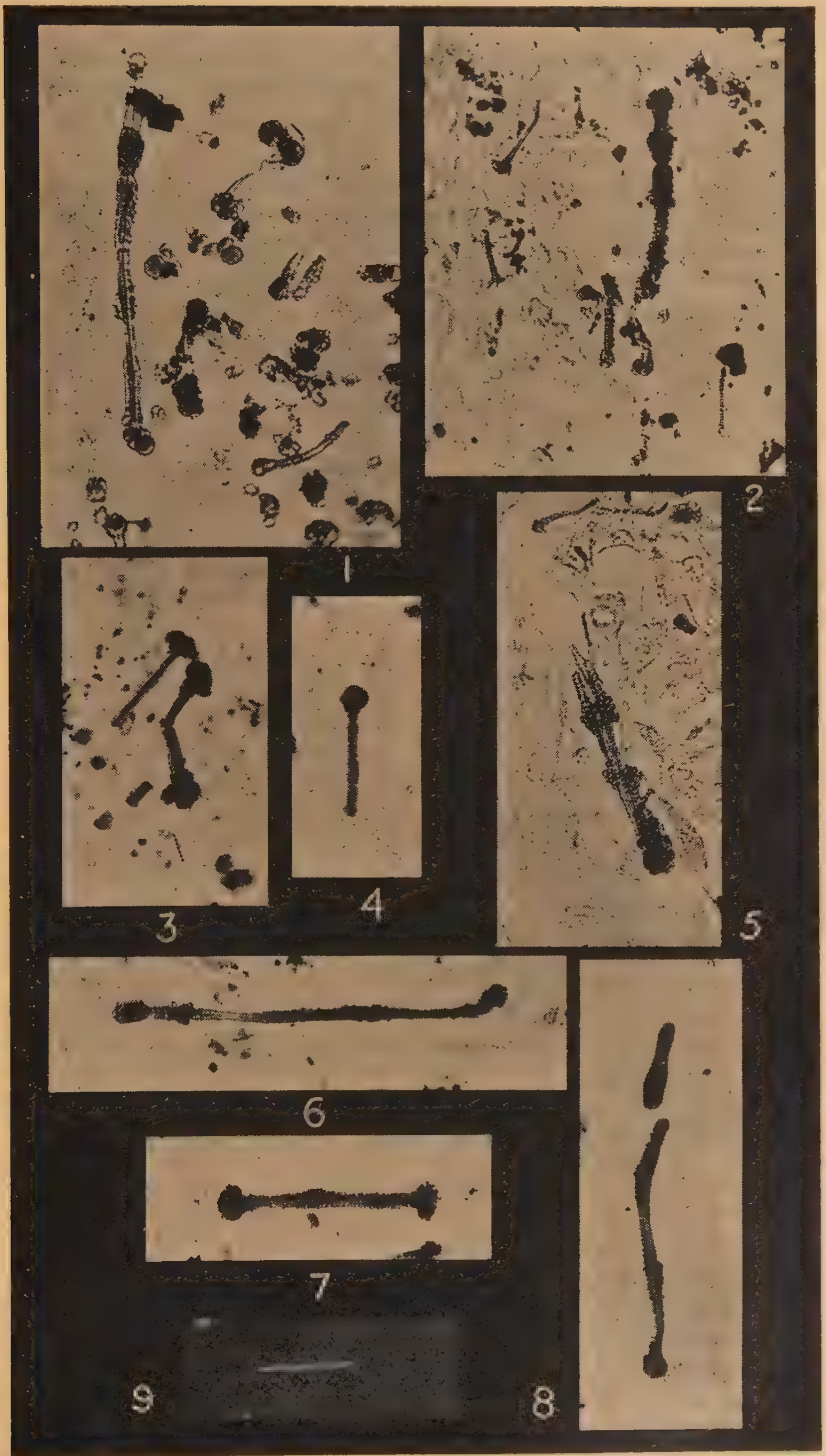


FIG. 35.—Asbestosis bodies. × 400 diameters. A few of the shapes and sizes of these bodies. Elongated dumb-bells, clubs with single bulbous ends, minute forms like a series of discs, single globular forms, etc. 3 and 4 show central core of black opaque mineral, cf. anthracotic bodies. In 8 the golden yellow casing has been fractured, exposing slender asbestos fibre core. The bodies may measure 100 to 120μ. In 9 the colloidal covering has been dissolved, leaving the fine asbestos fibre bare. Taken under polarized light. Photomicrographs by W. E. Cooke and C. F. Hill

stages there is fibroblastic proliferation in the alveolar walls and septa, and later, fibrosis becoming more marked, alveolar structure disappears and is replaced by dense fibrous tissue. Bronchiolectasis and chronic bronchitis are frequent features.

Asbestosis bodies

Sections taken from all parts of the lungs contain fine granular dust, large black particles and fragments of asbestos fibre (best seen under polarized light), and in addition the curious bodies which are characteristic of the disease. They are golden yellow in colour and vary in length from 2μ to 140μ or more. They appear as coccal forms single or in streptococcal-like chains, long forms with single or double bulbous ends, branched forms, and as strings of discs. In some a fine filament of asbestos fibre can be seen. There is a central core of asbestos upon which a colloidal combination of tissue-protein and silica has been adsorbed. This colloidal covering does not stain with aniline dyes but gives the Prussian blue reaction for iron: it is soluble in strong acids and alkalis which leave the central asbestos fibre bare. The bodies can be obtained in a pure state by tryptic digestion of the lungs. Their chemical composition is then found to be:

	Per cent
Organic matter	67·80
Inorganic matter	32·20

The composition of the ash was:

Free silica (SiO_2)	5·0
Combined silica	21·10
(Total silica, 26·10 per cent)	
Ferrous oxide	70·55
Magnesium oxide	2·55
Alkalis	0·80

The original asbestos did not contain any free silica and only 2·1 per cent of iron. The free silica in the analysis is probably due to changes in the asbestos fibre brought about by tissue fluids. The iron may possibly be derived from haemoglobin. These bodies are present in myriads in the lungs of patients with asbestosis, but may also be found, although very rarely, in normal subjects. Analogous bodies are seen in anthracosis (see Vol. I, p. 624).

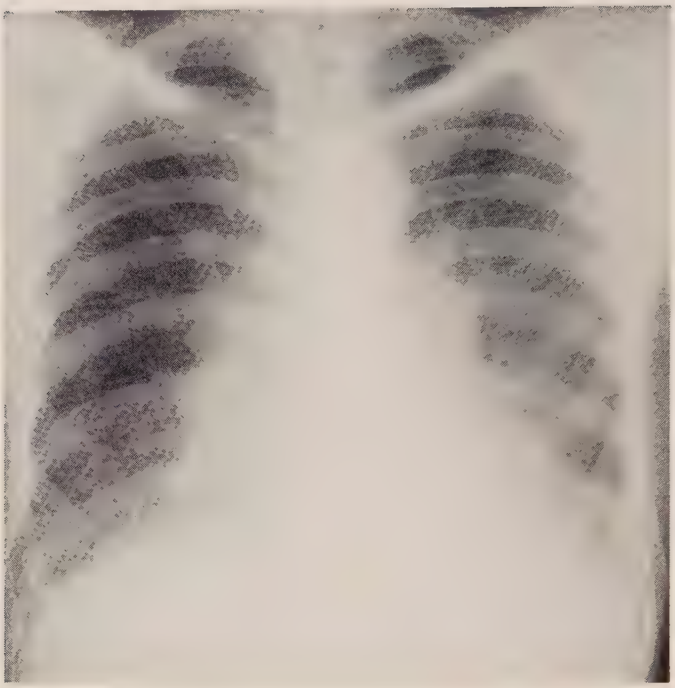
4.–CLINICAL PICTURE

Symptomatology

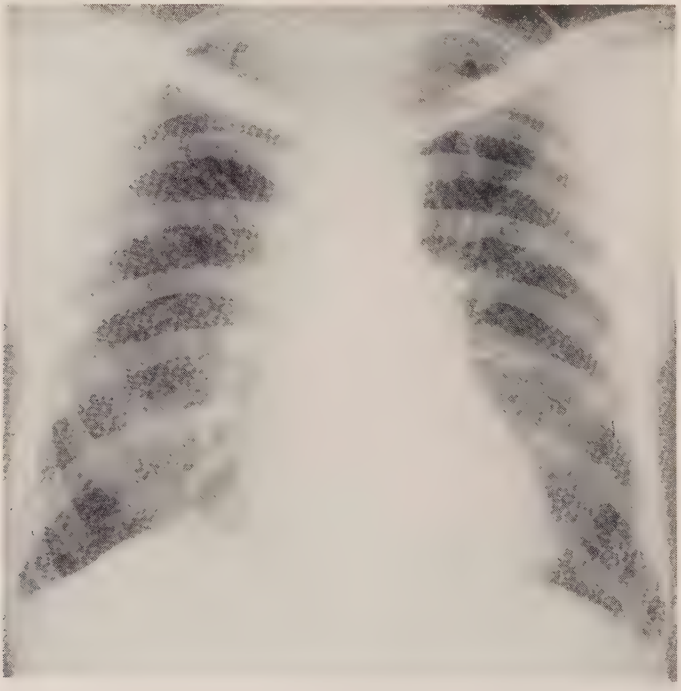
The onset is insidious. The lung condition may have existed for some years before an attack of influenza or a catarrhal cold focuses attention on it. The symptoms may appear very early, after only two to three years' exposure, or be delayed for fifteen years or more, depending upon the amount of asbestos dust inhaled.

Dyspnoea and cough

Dyspnoea is the most striking and probably the most important symptom. It is progressive whether the patient is removed from work



Early asbestosis in man aged 32 after 12 years' exposure. Peribronchial thickening and mottling, particularly at bases



Moderately advanced asbestosis in man aged 38 after 23 years' exposure. Marked fibrosis both lungs and generalized mottling.
(Both radiographs reproduced by kind permission of Dr. A. J. Lanza)

PLATE I

or not, and is primarily due to the pulmonary fibrosis and lack of diaphragmatic excursion, and later to deficient oxygenation and right heart failure. Some patients suffer from recurrent attacks of bronchitis, or chronic bronchitis and bronchiectasis with expectoration, others from a hard dry cough, but in a considerable number this is absent.

Loss of appetite and emaciation are frequent symptoms. The anorexia may be late or may occur whilst the patient is still working. Emaciation may be extreme even in the absence of tuberculosis. Cyanosis and clubbing of the fingers are also constant late manifestations. In addition to 'soreness', 'aching' and 'tightness' across the chest, which are common complaints, acute pain due to dry pleurisy or stretching of pleural adhesions occurs.

Physical signs

The physical signs are those of advancing pulmonary fibrosis with thickened pleurae, i.e. deficient chest expansion, bilateral impairment of the percussion note especially at the bases, weakened respiratory murmur over the bases behind, becoming harsher with prolonged expiration in front and over the upper chest, with fine râles and pleural creaks. With the advent of bronchiectasis or tuberculosis signs of cavitation may be present and spontaneous pneumothorax may occur. Finally oedema of the lungs, ascites and general dropsy supervene.

Fine spicules of asbestos penetrate the superficial layers of the skin, stimulate hypertrophy of the epithelium and produce small corns.

Radiological findings

Radiographs in early stages show a faint homogeneous haze in the lower part of the mid-lung fields, a ground-glass appearance, suggesting interstitial fibrosis. As the disease progresses, the haze spreads downwards through the lower two-thirds of the lung fields almost obscuring the domes of the diaphragm. The diaphragmatic excursion is much restricted. In the advanced stage there is a dense, diffuse fibrosis with prominent trunk shadows, obliteration of the left cardiac border, and pleural thickening. The picture is not in itself characteristic, but is a very valuable aid to the diagnosis (see Plate I).

5.–COURSE AND PROGNOSIS

The disease once established is progressive even if the patient ceases work in the industry, as asbestos dust trapped in the lungs continues to exert its fibrosing effects for many years.

Probable duration of life

The probable duration of life is impossible to estimate on the small numbers at present available, but the gravity of the condition is suggested by the cases in Table II, in which death took place on the average within five years of the last exposure to asbestos dust. This estimate will probably be found to be too pessimistic.

Complications

The risk of tuberculosis must be remembered and acute pulmonary infections—acute bronchitis and pneumonia—often cause death.

6.—DIAGNOSIS

Uses of asbestos

The manifold uses of asbestos in industry during recent years have enormously widened the risk of asbestosis and the disease may crop up in unexpected places. In addition to the mining, milling, carding, spinning and weaving risks, there are risks from the use of asbestos as heat-insulating for boilers and steam-pipes and as electric insulating material, and in the construction of electrical heating devices. It is used for mattress making, and is made up in different forms such as yarns, felts, boards, cloth, rope, cord, twine and threads. Asbestos cloth is made into suits for firemen and fire-proof curtains for theatres. Woven with metal wire it is used for brake linings for cars and machinery; and woven asbestos belts are used as conveyors for cement, clinker and other hot solids. Asbestos rope and string are used for steam-pipe and pump packing; and the acid-resisting properties of asbestos are utilized in filters for corrosive liquids. Pressed into blocks with cement, asbestos is manufactured into fire-proof cement, millboards, wall-boards, shingles and tiles. Asbestos sheeting is used to deaden sound in buildings, and asbestos paper where damp-proof and fire-proof coverings are required. Whole buildings, in fact, are constructed with asbestos materials.

For diagnosis, therefore, a complete and accurate occupational history, the presence of physical signs and symptoms of pulmonary fibrosis together with a good radiogram are the essentials. The presence of asbestosis bodies in the sputum, faeces, or fluid from a lung puncture is corroborative evidence that the fibrosis is due to asbestos. The physical signs, symptoms and X-ray picture are common to other pneumoconioses, but when they are taken with the industrial history a mistake is not likely to be made.

7.—TREATMENT

Prophylaxis

Dust prevention in all the manufacturing process is imperative. In its absence, workers in the more dusty process will not survive ten years. The preventive measures include periodical medical examinations, efficient localized exhaust ventilation at dust-producing points, enclosed mechanical conveyors, wet methods when possible, efficient cleaning systems and the use of breathing apparatus in certain operations.

When the disease is diagnosed the patient should be removed from further contact with asbestos. No measures can alter the lung condition existing at the time of diagnosis, nor apparently stay the advancing fibrosis, but it seems probable that life may be prolonged in hygienic surroundings where further infection is minimized, and useful work still carried on if regulated according to the capacity of the patient.

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ASCARIASIS

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1.–DEFINITION

105.] Ascariasis is an infestation by the nematode *Ascaris lumbricoides* and occurs in all latitudes. It is common in children, and occurs especially in persons whose habits are unhygienic.

2.–HELMINTHOLOGY

Ascaris lumbricoides

Several species of the genus *Ascaris* may infest the human host, but *Ascaris lumbricoides* is by far the commonest, the incidence of the others being negligible. It is a round-worm of stout body-build, pink or greyish-yellow in colour and resembles the common earthworm (*Lumbricus terrestris*) in shape. It has three lips roughly semicircular in shape, with fine marginal teeth, one papilla on each ventral lip and two on the dorsal lip. The male is about 15 cm. in length, but may reach 25 cm., and is 3 mm. thick. The female is about 25 cm. long, but may be 40 cm., and is 5 mm. in width. Both sexes are cylindrical, tapering at each end, particularly towards the head. The female is straight, whereas the posterior end of the male is curved ventrally and has two spicules projecting from the region of the cloaca. The body is transparent so that coils of uterine or testicular structures are visible through the body wall (see Fig. 36).

The eggs

The eggs are elliptical in shape with a characteristic mammillated layer deposited on the covering of the egg shell. On discharge from the host they are undivided and must be incubated before they can infect another host. They are highly resistant to unfavourable conditions, for although their development may be arrested by desiccation during the summer or by freezing during the winter they are not thus killed. The fertilized ovum requires from fourteen to forty days for development, the period varying with the conditions of incubation.

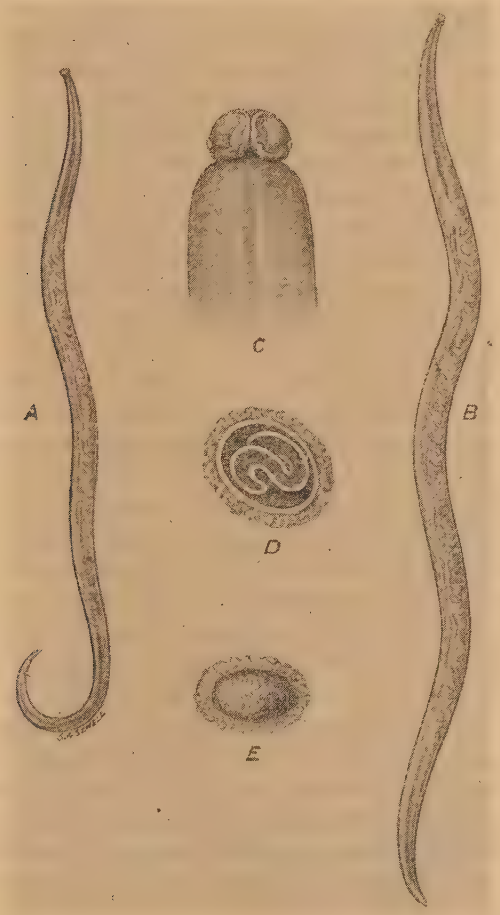

FIG. 36.—*Ascaris lumbricoides*. *A*, male worm; *B*, female worm; *C*, anterior end; *D*, embryo; *E*, egg

Life history

When an egg containing an embryo enters the stomach and reaches the intestine of the human host, the envelope bursts and the larva is set free. It penetrates the intestinal wall, reaches the veins or lymph vessels and is carried in the portal circulation to the heart. From there it is conveyed by the pulmonary artery to the lungs, penetrates the lung capillaries and reaches a lung alveolus. This occurs eight to ten days after ingestion, and at this stage the larva measures 1·5 to 2·5 mm. Then, adopting an independent migratory existence, it reaches the bronchi, and, aided by the ciliated epithelium of the trachea, is propelled into the larynx and pharynx, and is once more swallowed. Having reached the upper intestine it adheres to the mucous membrane and there develops into a mature ascaris five to six weeks after ingestion.

With more massive infestation some larvae may reach the general circulation, but it is believed that most if not all are killed. According to Ransom, however, some are conveyed to various organs. In this event, a local reaction in the tissues walls off the larva as a foreign body.

Experimental infection

The Japanese physician Koinos recorded that a healthy adult aged twenty-one swallowed 500 eggs and developed a slight pneumonia on the ninth day. Koinos himself took 2,000 eggs and developed very severe pulmonary symptoms of cyanosis, dyspnoea, cough and haemoptysis on the fourth day, followed by rigors on the sixth day. Larvae were found in the sputum on the third day, and on the fifth 178 were counted in 155 c.c. of blood-stained sputum.

This experimental work would seem to show that the view hitherto held, that the larva attaches itself to the intestinal mucosa on ingestion and there matures, is inaccurate, and that there is a preliminary migratory excursion in the human host as a definite phase in the life history of the parasite. Pulmonary symptoms are unusual in the ordinary infestation because the infection is slight, but Stiles recorded an instance in which four children in a family had pneumonia which eventually proved to be due to a heavy infection with larvae of ascaris.

Mode of infection

Infection depends upon the chance ingestion of eggs in which the embryo is fully developed. Such an embryo does not attempt to escape, and will, under favourable conditions, remain alive for five years or until it is set free by the digestive juices of the host. Infection is conveyed by raw food, such as lettuce and radishes, contaminated by the excreta of infected humans or animals. With children and in asylums where the standard of personal hygiene is low, there may be direct transmission of infected material. Contaminated water supplies are sometimes responsible and garden fertilizers employed to force vegetables used in salads are also a source of danger.

3.—PATHOLOGY

Migration of ascaris

Infestation with less than half a dozen ascarides may not give rise to any morbid lesion either in the journey of the larvae via the lungs or during the adult life in the intestine. The migratory habits of the adult worm, however, are notorious and it has been found in abscesses of the liver, pleurae and peritoneum; it has travelled up the oesophagus into the pharynx, passed into the Eustachian tube and eventually perforated the tympanum; it has been discharged at the umbilicus through a persistent omphalo-mesenteric duct, and has caused fatal asphyxia by impaction in the larynx in an attempt to reach the trachea from the oesophagus.

Massive infection

Massive infection gives rise to severe, and even fatal broncho-pneumonia, due to the multitudes of larvae in the pulmonary alveoli.

The possibility of damage to the intestinal mucous membrane with subsequent entry of infective bacteria is evident.

Toxic effects

A peculiar smell attributed to a toxic substance is noticed on handling the worm and Flury investigated a number of the metabolic substances which the worm produces. These include aldehydes, free volatile acids and the esters of certain organic acids. The continued formation of such substances may damage the intestinal mucosa, and remote effects in other organs might be expected from their constant absorption, thus accounting for the occurrence of symptoms resembling those of meningitis, chorea, hysteria, epilepsy, delirium, convulsions and cramps. Such conditions as dermographism, fleeting skin eruptions and vomiting may be the result of absorption of the toxic products of the worm; these products are, however, probably set free only on the death of the worm. The cessation of convulsions in a child on the evacuation of a dead ascaris was recorded by Still.

The presence of worms may cause intestinal spasm or even invagination or perforation of the intestine. Massive infestation has been responsible for intestinal obstruction by impaction, or as the result of intussusception. The relation of such conditions as appendicitis to worm infestation has not been properly assessed. The parasite, either as a larva or as a mature worm, may block the bile-ducts and so produce obstructive jaundice.

4.–CLINICAL PICTURE

In children

The ascaris is rarely solitary and the evacuation of one worm usually indicates the presence of at least one other. It is often, however, a relatively harmless parasite and may not give rise to any symptoms. The first indication of its presence may be the passage of one or more worms. On the other hand, indications of vague ill-health in a child may have suggested the presence of worms, but in such cases the mother has usually already administered a vermifuge.

Symptoms commonly attributed to ascariasis in children are irritability of temper, disturbed sleep, teeth-grinding, disordered appetite, irregular and abnormal motions containing mucus, abdominal pain, under-nutrition, pallor and nose-picking. In the absence of another explanation for any of these symptoms, a dose of santonin should be given; the evacuation of one or more ascarides would confirm the suspicion that they were responsible. It is equally probable, however, that such symptoms are but part of a vicious circle of chronic catarrh, chronic indigestion, improper diet and bad dietary habits.

In adults

In adults there may be discomfort after meals suggestive of a duodenal lesion, or even of chronic disturbance of the gall-bladder; in such a case ascariasis should be considered as a possible cause, especially if the patient has lived abroad.

The first and perhaps the only indication of the presence of ascaris may be the evacuation of the worm by the bowel or its appearance at some unexpected portal as a result of its migration.

Continental observers stress the relation of ascariasis to various dermatological conditions such as urticaria and certain erythematous lesions. Asthmatic attacks have been attributed to the passage of larvae through the lungs, but in such cases fever and haemoptysis occur. Eosinophilia is commonly regarded as a constant feature of worm infestation, but it is by no means constant.

5.–COURSE AND PROGNOSIS

When ascariasis is suspected and the patient properly treated, a successful outcome can be confidently promised. The worm rarely causes general symptoms such as would endanger life, except in those admittedly rare instances in which it migrates into other organs or tissues and necessitates surgical interference. The prognosis in such an event is determined largely by the organ involved and its accessibility for surgical treatment.

6.–DIAGNOSIS

The presence of vague symptoms which are not satisfactorily explained calls for the administration of an anthelmintic and examination of the evacuations. If for any reason it is not desirable to give santonin or oil of chenopodium the motions should be examined microscopically for ova. As the adult female ascaris produces a prodigious number of ova, only a minute portion of the faeces need be examined; a magnification of 100 diameters will reveal the characteristic ova if there is an adult female worm in the bowel. Eosinophilia, if present, may have some other explanation.

Ova in faeces

X-ray diagnosis

It has recently been shown that by a special technique, involving the entry of barium emulsion into the alimentary canal of the worms, their presence can be demonstrated by radiography.

Differential diagnosis

It is possible that a mistaken diagnosis of appendicitis, cholecystitis, duodenal ulcer or intussusception might be made in the presence of worms. Furthermore, vegetable matter in the faeces must not be mistaken for ascarides.

7.–TREATMENT

Prevention

A pure water-supply is an essential prophylactic measure in ascariasis. If the purity of the water supply is at all doubtful, then all water used in the preparation of food should be boiled.

Strict rules for personal hygiene should be enforced. Children should receive this instruction and be under supervision, as should also patients in institutions, such as mental hospitals, where the standard of hygiene is liable to be low.

Raw foods should be thoroughly washed in running water from a reliable supply, and foodstuffs used in salads must be protected from contamination by human or animal (especially swine) excreta. Artificial fertilizers are also potential sources of contamination.

The only satisfactory way of destroying worms which have been evacuated by the host is by incineration.

Drugs

A preliminary purge with a saline cathartic, and a fluid diet for twenty-four hours should precede the administration of an anthelmintic.

Santonin dosage

Santonin is the drug of choice for ascariasis. It is given with calomel either as a powder, a tablet or a lozenge. One grain each of santonin and calomel is sufficient for a child of two years, and it is a good plan to spread the powder between bread and butter. For an adult, three grains of santonin should be given. On the following morning it is advisable to order a full dose of magnesium sulphate or a Seidlitz powder.

Santonin with castor oil

Santonin is soluble in oils (1 in 200 of castor oil), and it is therefore often advised that castor oil should not be given at any time during the treatment. J. A. Gunn, however, supported Kuchenmeister in the observation that santonin acts more satisfactorily when given in this vehicle, and stated that unpleasant symptoms were not observed and that the risk of ill-effects was considerably lessened. The so-called 'golden' santonin, made by exposing santonin to bright sunlight, possesses no advantages over the ordinary variety.

Sensitiveness to santonin

Yellow vision (xanthopsia) and reddish-coloured urine (xanthuria) may follow santonin administration, and although they are harmless the possibility of their occurrence should be explained beforehand to the mother or to the patient. In specially sensitive individuals severe vomiting, nervous excitement, headache, convulsions or delirium may arise with or without haematuria, dyspnoea, xanthopsia and xanthuria. These effects are exceedingly rare and should be treated by the same measures as would be adopted in a case of poisoning, namely, by stomach lavage and the administration of sedatives by the rectal route.

Oil of chenopodium

American wormseed oil, oil of chenopodium, has been favourably recommended in the treatment of ascaris infestation, but its dosage must be carefully estimated as fatalities have followed its careless administration. For a child one drop for each year of age is a safe dose and an adult may take 15 minims, although 10 minims is generally sufficient. Administration is by capsule or on a lump of sugar.

With carbon tetrachloride

It has been suggested that carbon tetrachloride (1 drachm) is a good solvent of oil of chenopodium. If this combination is given it should be followed two hours later by a saline cathartic or a purgative dose of castor oil. This is because it is believed that the worms are not killed by the drug and are evacuated only on free and immediate purgation.

Poisoning by chenopodium

Poisoning by oil of chenopodium has a very high mortality; it is characterized by vomiting, dizziness, somnolence or stupor, and possibly convulsions. The treatment is gastric lavage, the administration of sedatives by the rectal route, and respiratory stimulation.

Subsequent treatment

As the ascaris requires about six weeks to mature, there is no need to repeat the treatment until six weeks have elapsed, and a similar period should elapse before the faeces are re-examined.

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ASCHHEIM-ZONDEK TEST

See PREGNANCY: NORMAL AND PATHOLOGICAL

ASCITES

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Reference may also be made to the following titles:

HEART DISEASES
LIVER DISEASES
NEPHRITIS AND NEPHROSIS
OEDEMA
PERITONITIS

1.—DEFINITION

106.] Ascites is defined as a collection of non-purulent fluid in the peritoneal cavity. Pus is excluded in order to preserve a practical rather than an academic outlook, since clinically a collection of pus entails a serious illness embracing much more than a mere accumulation of free fluid in the peritoneal cavity, and the investigation of such a case should be approached from an entirely different angle, namely, the diagnosis of deep suppuration. Ascites, on the other hand, is as a rule a major physical sign and the problem is the discovery of its cause.

2.—CAUSES OF ASCITES

Simple fluid in the peritoneal cavity may be a part of a general oedema, or it may be due to (*a*) irritation of the peritoneum, (*b*) obstruction in any part of the veins draining the abdominal cavity, i.e. the portal vein, or (*c*) obstruction of the thoracic duct. A pathological classification, however, is of more value for descriptive than for practical purposes, and a clinical grouping is preferable.

Clinically, cases of ascites fall into two groups: (1) those in which it is

Classification of causes

part of a general oedema and (2) those in which there is little or no oedema elsewhere. In the first group the diagnosis is easy if a complete physical examination of the patient is made; in the second group some of the causes are easy to diagnose, others very difficult. The following list gives the causes of ascites in condensed form:

(1) Ascites with general oedema: (*a*) Heart failure—mitral stenosis, coronary disease, chronic lung disease, emphysema, scoliosis, Ayerza's disease; (*b*) Kidney disease—acute nephritis, chronic nephritis; (*c*) Anaemia.

(2) Ascites without general oedema: (*a*) Tuberculosis—tuberculous peritonitis, Concato's disease; (*b*) Cirrhosis of the liver—portal cirrhosis, haemochromatosis, Banti's syndrome, syphilis, Pick's disease; (*c*) Malignant disease of the peritoneum—secondary to carcinoma of the abdominal viscera, including the ovaries, of the breast, and other parts; (*d*) Obstruction in the hilum of the liver (ascites with jaundice); (*e*) Obstruction in the thoracic duct (chylous ascites); (*f*) Rare venous obstructions; portal thrombosis, obstruction of the hepatic veins.

(1)—Ascites with General Oedema

Heart failure

Any severe right ventricular failure, causing passive venous congestion, will lead in time to ascites. The commonest cause is mitral stenosis, with or without other rheumatic lesions of the valves or pericardium, but coronary disease, whether atheromatous or syphilitic, may be the basis of the heart failure. For instance, aortic regurgitation in middle-aged men may be complicated by syphilis of the coronary arteries, and give the complete clinical picture of congestive failure. In cardiac cases the ascites is preceded by great oedema of the legs. The degree of heart failure will necessarily be severe, and the diagnosis will be made easy by the cyanosis, venous pulsation in the neck, dyspnoea, auricular fibrillation, and the past history of the cause of the heart disease, usually rheumatism. The heart is obviously enlarged, and murmurs confirm the diagnosis. The liver, if accessible to the hand through the fluid, is enlarged, rounded, tense and probably tender, the urine is scanty and dark and contains a little albumin (passive congestion of the kidneys), but an erroneous diagnosis of hepatic cirrhosis on the one hand, or of nephritis on the other, will be avoided by a systematic examination of the patient.

Chronic lung disease

Chronic lung disease, which inevitably leads to right ventricular difficulty, may cause ascites. Advanced emphysema or extensive pulmonary fibrosis should be easily diagnosed by the pulmonary signs.

Scoliosis

Scoliosis, another cause of severe congestive heart failure, can be diagnosed at sight. The French stress the 'hunchback's heart', but in this country it tends to be ignored: it is not very common, but it is a very definite clinical picture and this form of cardiac failure is rapidly fatal.

Ayerza's disease

Ayerza's disease (endarteritis of the pulmonary artery) is rare and should be diagnosed with caution. The clinical picture is that of an apparently cardiac congestive failure, with right ventricular enlargement but without murmurs, and the diagnosis is usually made by exclusion.

It may be confirmed by a blood count, as there is usually an increased red cell count, up to 10 million per cubic millimetre.

Age incidence

Ascites from mitral stenosis is most frequent in women between the ages of thirty-five and forty-five; syphilitic coronary disease and severe emphysema are found in men of forty-five to fifty-five, the former in the thin, the latter in the fat. Patients with scoliotic heart failure are almost always young adults. Ayerza's disease is least rare in adolescents and children. Rheumatic mitral disease has seldom had sufficient time to develop to this extent in childhood, but at puberty ascites may be caused by a combination of mitral stenosis and adherent pericardium which had started at the age of six or seven. Congenital heart disease seldom causes ascites; if it does, the fundamental lesion is pulmonary stenosis or Fallot's tetralogy and the diagnosis is easy.

The fluid in all these conditions is clear, straw-coloured and contains about 0·5 per cent of protein.

The immediate prognosis is bad in all cardiac ascites except that of mitral stenosis, and, even then, neither a useful nor a long life is to be expected.

The special treatment for any form of cardiac ascites is rest, and digitalis in adequate doses. This may be followed by very remarkable improvement, but if not, the wisest procedure is to tap the ascites, and then diuresis due to the digitalis will often set in and the ascites diminish. It is advisable to keep these patients on a very light diet with no more water than is necessary, and to give additional glucose, which will supply the heart muscle with energy even when the diet is inadequate. The mercurial diuretics may be used, but digitalis usually makes them unnecessary.

Kidney disease

Ascites forms part of the general anasarca of acute nephritis and 'chronic parenchymatous nephritis' or 'nephrosis'. The diagnosis of renal origin is made on the general clinical picture of nephritis and the urinary changes. The early oedema of the eyelids is very characteristic of nephritic oedema, and the illness, pyrexia, furred tongue, rising blood-pressure, and, possibly, early uraemic symptoms of acute nephritis, are obvious. In the chronic parenchymatous form there is much less 'illness' and no uraemia or rise of blood-pressure, but the anasarca at once directs attention to the urine, which in both these forms of renal disease is loaded with albumin. A trace of albumin may be found in the urine of any patient with ascites, but the dense cloud in nephritic cases is diagnostic. The presence of casts, cellular or granular, confirms the diagnosis.

The ascitic fluid usually resembles that of cardiac ascites, but in chronic parenchymatous nephritis it may be 'pseudo-chylous', i.e. milky, owing to the presence of lipoid as distinct from fat.

The prognosis of a case of acute nephritis with ascites is worse than that of one without, but recovery is quite common, although the disease may pass into the chronic form rather than recover completely. The prognosis in chronic parenchymatous nephritis is the gravest in the whole class of the nephritides; death within two years is almost certain.

The general treatment (see p. 162) is applicable, with certain additions. In acute nephritis nothing but glucose-water should be given in the first place and the diet should be severely restricted as long as blood is present in the urine. Sodium bicarbonate or potassium citrate may be given in full doses. In chronic parenchymatous nephritis a simple vegetarian diet is as effective as great restriction, and alkalis are unnecessary and indeed pointless if a restriction of salt is to be tried. In both forms diaphoresis by hot-air baths may be used, taking due care that inability to sweat does not lead to a dangerous rise of temperature. The mercurial diuretics are probably harmless in the more chronic cases, but most medical practitioners hesitate to attempt so to treat an acutely inflamed kidney.

Anaemia

Any severe anaemia may cause oedema, and with it a little free fluid in the peritoneum, but clinically this scarcely constitutes ascites and does not need any further mention, except that myelogenous leukaemia occasionally causes chylous ascites. This is more likely to be due to the pressure of glands on the thoracic duct than to the anaemia.

(2)—Ascites without General Oedema

In most of these cases a large ascitic effusion is found, with few other signs on which to base a diagnosis, so that on the whole it constitutes a much more difficult group than the former. Fortunately, most of the very difficult diagnoses are rare.

Tuberculous peritonitis

One of the classic clinical types of tuberculous peritonitis is the 'ascitic'. In this the doughy abdomen and the palpable masses of the plastic type are not to be expected, nor is the occasional intestinal pain nearly so common. As a rule the patient, a child or young adult, is brought for advice on account of swelling of the abdomen or of wasting of the rest of the body. There is a history of a very slow gradual onset, with general languor rather than illness, occasional or continued fever, not as a rule very high. There is a little disturbance of the bowels, either constipation or diarrhoea, and a very characteristic increase in size of the abdomen which contrasts with the wasting of the limbs. Such an ascites, without oedema of the ankles, in a young person, is almost invariably tuberculous, and the diagnosis is not difficult. It is in the other forms of the disease that difficulty arises.

The fluid contains 10 to 14 per cent of protein, lymphocytes and often red blood cells. Effusions containing a few red blood cells are either tuberculous or malignant.

The prognosis of the ascitic variety of tuberculous peritonitis is better than that of the others, and it improves in proportion to the age of the patient. The possibility of a relapse must be remembered in giving a prognosis.

Treatment should be directed to the cause: the general treatment for ascites is inapplicable. The first essential is absolute rest in bed, in the open air, preferably by the sea. Diet should be liberal and cod-liver oil should be given; judiciously applied sunlight gives good results. Laparotomy, simply draining the fluid and exposing the peritoneum to the air, although it seems an elaborate method of doing very little, is often followed by cure, and is well worth doing in cases which persist in spite of ordinary treatment.

Concato's disease

Concato's disease, though doubtfully tuberculous, is the association of ascites with pleural and sometimes pericardial effusions. The effusion is accompanied by a proliferation of the serous membranes concerned, and in the case of the peritoneum this is called 'chronic proliferative peritonitis' and has been regarded as the cause of the effusion. There is little doubt that the proliferation is the result and not the cause. The prognosis is poor, and the only treatment, symptomatic aspiration.

Cirrhosis of the liver

Any hepatic cirrhosis may cause ascites, but the usual association is with 'multilobular' cirrhosis. Although they have features in common, it is convenient to divide the cirrhoses into (*a*) those with ascites without jaundice (multilobular) and (*b*) those with jaundice and without ascites (unilobular).

The ascitic fluid in all cases of cirrhosis contains about 2·5 per cent of protein. The figure may be rather lower, from contamination with oedema fluid of toxic origin, like the oedema of the ankles. If it is higher it may indicate malignant change (cirrhosis carcinomatosa) or secondary tuberculous peritonitis. The latter is said to be common, but it seems statistically that although pulmonary tuberculosis is common in cirrhosis, tuberculous peritonitis is rare.

Common cirrhosis

In common cirrhosis ascites is a usual terminal complication. It is preceded by anorexia, alternating diarrhoea and constipation, and usually wasting and haematemesis. The ascites is also preceded by slight oedema of the ankles: this is not usually noted, but can always be found if looked for carefully. The liver is more often enlarged and palpable by dipping (or after paracentesis) than diminished in size, and the enlarged veins on the abdomen flow away from the umbilicus. There is almost always a latent obstructive jaundice detectable by the van den Bergh test, though clinical jaundice is hardly perceptible. Common cirrhosis characteristically occurs in middle-aged males usually with an alcoholic history. It is often difficult to obtain an alcoholic history in women with cirrhosis.

Haemochromatosis

Haemochromatosis, in the ascitic stage, shows all the signs of common cirrhosis, with the addition of the bronzed skin, diabetes mellitus, and loss of axillary hair. The liver is always much enlarged. It is rare in this country but so characteristic that diagnosis is easy. The patients are usually middle-aged males; when it affects females, it is often associated with myxoedema.

Splenic anaemia

Splenic anaemia is an unsatisfactory diagnosis (see Vol. I. p. 450); when complicated with hepatic cirrhosis it is known as Banti's syndrome and is accompanied by ascites. There are three age-groups in which the terminal stages of cirrhosis usually occur—6 to 9, 16 to 23 and 43 to 48. Most cases of splenomegaly, hepatic cirrhosis and ascites in young persons fall into the first group, which is often called syphilitic; the second is called the 'splenic anaemia' group; and the third, the common cirrhosis group. The ascites, its concomitant features and treatment, are the same in all groups.

Syphilis

Congenital syphilis may lead, if the patient survives, not only to fibrosis but eventually to true cirrhosis of the liver. These patients are usually about the age of puberty, and Hutchinson's triad makes the diagnosis simple. The Wassermann reaction may be negative, the disease being no longer syphilis but cirrhosis, the treatment and prognosis of which are applicable. In late middle-age the effects of extreme gummatous scarring may cause ascites. The liver is then the 'hepar lobatum' and feels like a mass of hard lumps. The erroneous diagnosis of malignant disease may be avoided by examination of the ascitic fluid.

Pick's disease

Pick's disease is the very rare pseudo-cirrhosis following chronic pericarditis. Although the associated heart failure may have caused oedema of the legs when the patient is first seen, a period of rest in bed clears up practically all oedema except the ascites, which remains very large. The clinical picture is then typical: a large ascites with wasted limbs, a cor bovinum, often accompanied by rheumatic valvular disease, with systolic retraction of the ribs and often a prominence of the left side of the chest. The lower ribs are frequently everted by the ascites. The patients are usually children or adolescents.

Malignant deposits in the peritoneum

Miliary secondary malignant deposits on the surface of the peritoneum cause progressive and incurable ascites. The usual primary foci are the stomach and breast, but malignant growths in almost any position may give rise to metastases in the peritoneum. Solid ovarian carcinoma is very liable to do this, but before operating it is essential to make sure that there is not a primary carcinoma of the stomach which has infected both ovaries (Krukenberg's tumours). Papilliferous ovarian cysts may rupture or penetrate and give rise to widespread warty growth in the peritoneum, with ascites. It is said that removal of the cyst leads to spontaneous disappearance of the peritoneal implants. I cannot find any first-hand evidence of this and suspect that the statement is copied from book to book. This, however, is no reason for refusing to operate and thus leaving the patient to die.

The incidence of malignant peritonitis is highest in late middle-age and in women. The fluid contains endothelial cells, lymphocytes and red blood-corpuscles and about 5 per cent of protein. The prognosis is, of course, hopeless.

Treatment is purely symptomatic, but tapping should be withheld until the patient's comfort demands it, and a liberal supply of salt should be maintained in the diet. Opinions vary, but if there is the least doubt about the diagnosis laparotomy should be performed; a curable disease may be found.

Obstruction in the hilum of the liver (ascites with jaundice)

Ascites with jaundice is the characteristic clinical picture caused by tumours of any sort in the hilum of the liver, because any swelling in this situation tends to obstruct both the portal vein and the common bile-duct. Such swellings may be tuberculous glands, Hodgkin's disease or secondary malignant deposits, carcinoma of the head of the pancreas, aneurysms of the hepatic artery or coeliac axis, or gummata. The ascites usually appears before the jaundice, but seldom reaches a great size without it. Localization of the disease is therefore as a rule easy, but the determination of its nature is often difficult or even impossible. The most obscure cases are fortunately those which can be cured by operation. Tuberculosis is rarely confined to this site alone, and can be diagnosed by the pyrexia and the discovery of similar lesions elsewhere. In Hodgkin's disease, even if the superficial lymph glands are not involved, the spleen will probably be enlarged and the Pel-Ebstein temperature is common in abdominal lymphadenoma. Cancer of the hilar glands is rare without clinical evidence of metastases in the liver, in fact the jaundice and ascites are usually (erroneously) attributed to these. Intrahepatic deposits alone seldom cause either. The ascitic fluid in all these cases is jaundiced and contains about 2·5 per cent of protein.

Obstruction in the thoracic duct (chylous ascites)

Chylous ascites may be suspected from the wasting of the patient and the absence of evidence of the other varieties, but the diagnosis can be established with certainty only by aspiration. The fluid has the appearance of milk, and on standing a layer of fat, extractable in ether, will separate. The causes are: obstruction of the thoracic duct by enlargement of glands of any kind, mechanical injury and, more rarely, myelogenous leukaemia. Operative treatment is sometimes successful, either by removing the cause or by establishing a collateral circulation, but the prognosis is in most cases very bad, and the patient suffers not only from the ascites but also from the inability to absorb fat. The diet should therefore contain greatly increased amounts of carbohydrate; fat is useless and better excluded, but the glycerin component of fat may be given, as a sweetening agent.

Rare venous obstructions

Portal thrombosis and stenosis of the ostia of the hepatic veins may cause ascites.

Portal thrombosis

Portal thrombosis is usually secondary to cirrhosis of the liver or thrombosis of the splenic vein, or is one of the multiple thromboses of cancer or thrombophlebitis migrans. The primary disease is generally evident before the ascites appears. The prognosis is extremely variable, but one may say that patients with cancer will probably live for a few weeks or months; thrombophlebitis migrans may attack the pulmonary vessels with a fatal issue at any time, and cases due to cirrhosis of the liver are practically undiagnosable, but may be found post mortem to have lived a long while after the thrombosis.

Septic thrombosis of portal vein

Septic thrombosis of the portal vein giving rise to multiple abscesses of the liver used to be fairly common. In my experience the only form now seen is a staphylococcal suppurative thrombosis causing ascites, toxic hepatitis and broncho-pneumonia. The clinical picture is characteristic and consists of a sudden onset, with a Hippocratic facies, ascites, a swollen tender liver, blood-stained sputum, patchy pleurisy and a very high leucocytosis up to 60,000 polymorphs per cubic millimetre. The temperature is high and swinging. The patient wastes and dies in two to four months. Treatment is of course hopeless as it is impossible to drain a vein.

Obstruction of hepatic veins Thrombosis of the hepatic veins, of which Budd described a case, and extraordinary obliterative stenosis of their openings, also give rise to ascites. The acute cases prove fatal before ascites develops; in the chronic cases the patients complain of epigastric pain and abdominal swelling (ascites); the liver is large, tense and tender, there is a collateral circulation like that in cirrhosis, and cyanosis of the lips, ears and finger-tips is present. In other words the picture is that of ascites of the cirrhotic type, with a nutmeg liver and cyanosis, and no cardiac lesion. The patients ultimately die of failure of hepatic function. No treatment has up to the present been successful as the circulation through the liver is stopped, but roughening of the diaphragm and liver capsule to establish a direct collateral circulation may be tried.

3.–DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

This question arises in two forms: (1) diagnosis from other abdominal enlargements and (2) the aspiration of a small quantity of fluid for additional laboratory investigation of its cause.

The patient complains of an increasing abdominal enlargement which, if great, may cause dyspnoea by upward pressure on the diaphragm, dyspepsia and wasting by interference with the functional activity of the abdominal organs, oedema of the ankles and oliguria by pressure on the kidney vessels, and, if the patient is ruptured, an increase in the size of the hernia. There is not any loss of weight, for although the patient may become noticeably thinner, the total body-weight naturally increases. The symptoms are very variable; indeed, an effusion which forms very slowly may reach a great size without causing any symptoms: a small effusion gives rise to no symptoms.

Appearance of abdomen On examination the abdomen is uniformly and symmetrically enlarged in proportion to the size of the effusion. A small ascites will sag into the flanks, making, between the ribs and the iliac crests, a flabby bulge which will alter with the position of the patient. A large effusion will cause a rounded abdomen, also protruding in the flanks, but becoming more and more spherical, with the navel at its highest point. The skin will then be stretched, tight and shining, with striae albicantes. The umbilicus will be flattened or actually everted. The veins of the abdominal wall become unusually visible, even when they are not enlarged as part of a collateral circulation.

Palpation On palpation, in extreme cases the abdomen is as tight as a drum and nothing at all can be felt. Equally little will be felt when there is a small effusion, but in most cases dipping on to the liver gives a quite characteristic sensation, like ballottement, which is practically diagnostic. The same sign is present when there is free gas in the peritoneum, but this is excessively rare and easily distinguished by percussion. The other palpation sign is the fluid thrill, the transmission of an impulse from one side of the abdomen to the other. To elicit this an assistant must place the edge of his hand vertically on the centre of the abdomen to cut out transmission through subcutaneous fat, the physician then places one hand on one flank and flicks the other flank with his finger; the sensation of the tap is felt, in an almost exaggerated form, by the opposite hand. A fluid thrill will be found only when the fluid is sufficient to cover the spine and connect the pool in either flank.

The fluid thrill

Percussion

On percussion the abdomen is dull, the dullness being in the flanks and above the pubes in a horseshoe form, with, in the centre, the resonance of the intestines, floating in the fluid. The characteristic of free fluid is that the dullness shifts with the position of the patient. There are three ways of eliciting this sign. (*a*) With the patient lying on the back, percuss from the centre of the abdomen towards the flank until a definitely dull note is obtained; and then with the pleximeter finger in position the patient is rolled on to the side, and after a few seconds percussion is repeated. The note will now be tympanitic if the dullness is due to free fluid. (*b*) The patient is rolled a little to the right side and the right flank percussed with the pleximeter finger firmly but gently applied to the skin over a definitely dull spot. The finger is then pressed into the abdominal wall, and percussion continued. If fluid is displaced and the abdominal wall comes against the caecum, the note will become resonant. If the pressure is relaxed, the dullness returns. It is important to press rather firmly the whole time, as a dull note is always obtained when the pleximeter finger is loosely applied to the skin; falsely positive results may be obtained if this precaution is ignored. (*c*) If there is very little fluid, it is sometimes possible to detect it by peri-umbilical dullness with the patient in the knee-elbow position. This procedure is apt to be more comic than useful.

Aspiration of ascitic fluid

Finally, the diagnosis may be confirmed by aspiration. An elderly physician has said that it is pointless to consider the physical signs of ascites, as experimental aspiration is so much quicker and simpler. It is true that puncture of the normal abdomen is perfectly safe, but if the intestine is held by adhesions (and it is difficult to be sure that it is not) there is a risk of puncture and peritonitis. The method is slightly more unpleasant to the patient, but should not be despised, as it both makes the diagnosis certain and provides a sample of the fluid for examination. The details of the technique of paracentesis are given below (see p. 163).

Loculated ascites

Loculated ascites is a collection of fluid free in part of the peritoneal cavity, but shut off from the rest by adhesions; it is rare, and exceedingly rare from any cause other than tuberculous peritonitis or cancer. The diagnosis may be indicated by shifting dullness or fluid thrill, but is often made only by the establishment of the diagnosis of the fundamental cause, or by aspiration.

Differential diagnosis

Other abdominal swellings may be excluded easily if the dullness is of horseshoe shape and shifts with the position of the patient, and if there is a fluid thrill. The following are occasional sources of error:

From distended bladder A distended bladder projects characteristically at its upper end in the mid-line, and disappears after the passage of a catheter (an essential preliminary to paracentesis in any case).

From cysts Ovarian cysts, if large, and especially if bilateral, produce dullness of irregular distribution, and can be felt by vaginal examination.

Omental, pancreatic and hydatid cysts are fortunately rare, as the diagnosis is very difficult; mistakes may often be avoided if importance is attached more to the distribution of the dullness with the patient lying on the back than to the thrill.

From hydronephrosis A large hydronephrosis should not be mistaken for ascites, since a unilateral hydronephrosis would not give ascitic signs on careful examination, and bilateral swellings would probably be associated with a full bladder, which could be emptied by catheter but not voluntarily.

4.–TREATMENT

Certain points in treatment depend, of course, on the cause, as ascites is only an end-result of many diseases and not a disease in itself. In general, however, any effusion may be treated by diet, drugs and operative measures.

Diet Dieting is often attempted, but is not of great value. The restriction of fluids and elimination of salt from the diet may help in nephritic ascites, but it is not justifiable to restrict fluids to the point of causing discomfort, and a salt-free diet must not be pressed if the fluid is aspirated. It is easy to cause a serious and possibly fatal salt depletion, with a form of 'uraemia' similar to that seen in severe vomiting, by the repeated removal of the large quantities of sodium chloride contained in an abdominal effusion, if the total salt-content of the body is not maintained by the diet.

Purgative drugs Purgation is of little value. It is simple to cause a large fluid loss by this means, but it usually leads to a compensatory oliguria, and drastic purgation of an ascitic patient is very exhausting.

Diuretics Diuretics, until recently, have also been disappointing, though theobromine with sodium salicylate is well worth a trial. The powerful mercurial diuretics, such as neptal and salyrgan (mersalyl), which are now available may lead to complete disappearance of an effusion. They are likely to be ineffective in malignant or tuberculous peritonitis and must be used with great care in nephritis as the mercury may damage the kidneys, but they are of the greatest value in the other forms. Even in cases of nephritis (of the hydraemic, chronic type) they do, as a rule, more good than harm and are not to be shunned on purely theoretical grounds. To obtain the full effect the patient may be given ammonium chloride in a palatable mixture, 15 grains four times a day, for three days; e.g. ammonium chloride 15 grains, liquid extract of liquorice 30 minims, distilled water to 4 fluid drachms. Then give, by injection, 0·5 c.c. of the diuretic, in order to test the tolerance of the patient, and next day, continuing the ammonium chloride all the time, inject 1 or 2 c.c., according to the weight of the patient and the reaction to the test dose. This is often followed by a most remarkable diuresis and diminution of the effusion. An interval of approximately five days should be left between doses. The drug is put up in ampoules ready for injection, and may be given intravenously or, better, intramuscularly, as its action is thus more prolonged. An even greater effect may be obtained by taking 1 to 5 c.c. into a 20 c.c. syringe, aspirating some ascitic fluid into the syringe to dilute the dose, and then injecting the mixture back into the peritoneal cavity.

Operative treatment

Surgical treatment includes the minor operation of tapping and the major Talma-Morison operation.

Paracentesis

Paracentesis is a simple matter but is not performed as often as it should be. It labours under the dictum that 'ascites in cirrhosis is only tapped three times before the patient dies'. That is true, not because paracentesis kills the patient, but because ascites is a terminal complication. Tapping makes the patient much more comfortable, and by relief of pressure on the renal vessels often starts a diuresis with or without assistance, which would not otherwise occur.

The method of performing paracentesis is as follows: Put a many-tailed abdominal bandage in readiness under the patient and pass a catheter; voluntary micturition is not sufficient, and without this precaution the bladder is very liable to be punctured. Then find a point in the mid-line between the pubes and the umbilicus which is definitely dull to percussion, sterilize the skin with iodine or 70 per cent alcohol, or even better with one drop of liquefied phenol, which acts both as an antiseptic and as a local anaesthetic. The tissues may be anaesthetized with novocain down to the peritoneum. It is best to make a tiny stab incision through the skin with the point of a scalpel, as the skin tends to drag round a trocar. Perform the paracentesis firmly and in one movement, with a small trocar and cannula (Southey's tube does very well) to which a length of thin rubber tubing has been attached, through which the trocar is inserted. On withdrawing the trocar the puncture in the rubber tube closes and the fluid may be drained conveniently into a bucket at the bedside. Fix the cannula in position with strapping, putting a small piece of gauze between the plate and the skin, put a generous piece of wool on the abdominal wall and fasten the many-tailed bandage firmly over it. Allow the fluid to drain out slowly and tighten the abdominal bandage frequently; if the abdominal pressure falls suddenly the patient will collapse.

Talma-Morison operation

The Talma-Morison operation consists of sewing the omentum to the anterior abdominal wall, or of rubbing the peritoneum off the liver and the diaphragm so as to lead to the formation of an artificial collateral circulation. In cases of hepatic cirrhosis it is sometimes successful, though apt to be disappointing, but in cases in which the diagnosis is in doubt it may well be combined with exploratory laparotomy, and often succeeds even though the diagnosis is never established.

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ASPERGILLOSIS

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Reference may also be made to the following title:
FUNGOUS DISEASES

107.] Primary disease caused by the fungus *Aspergillus* is rare in man and animals. The fungus belongs to the Fungi perfecti, which are invariably less invasive than Fungi imperfecti, such as ringworm. The organism consists of coarse septate mycelial threads with hyphae; at the ends of the hyphae are large numbers of spores. These are distributed by the air and when implanted on a suitable pabulum give rise to colonies of the fungus. The colonies are usually pigmented, the colour varying with the reaction of the medium, being brownish-black in alkaline and greenish in acid media. The colonies comprise many of the moulds which appear on foodstuffs or laboratory media.

Pathology

The commonest species (see Fig. 37) is *A. fumigatus* (black or green); others are *A. flavus* (yellow) and *A. repens* (green). Spores often alight on the skin and are inhaled into the nose or deeper into the respiratory tract. It is rare for the fungus to exert a primary invasive action on a healthy membrane, but in unhealthy tissue, such as a lung cavity infrequently cleared or an ulcerated surface imperfectly cleaned, or around a foreign body which is itself a suitable pabulum, colony formation may occur.

Rénon (1897), in a monograph on aspergillosis, reviewed the different types of lesion that have been ascribed to the fungus and expressed a strong opinion on the pathogenicity of the organism. British opinion regards the organism as an extremely rare cause of primary disease of the lung, as an occasional secondary invader in cases of pulmonary tuberculosis, and as found from time to time implanted on an unhealthy, usually ulcerated, cutaneous or mucous surface in unclean people, or in sites difficult to clean, or on a foreign body. Lesions due to aspergillus have been described in the lung, the eye (corneal ulcer), the ear (otomycosis), in the nose, urethra, and on the skin.

Pulmonary aspergillosis

The lung lesion is often spoken of as pseudo-tuberculosis because the mycotic nodules consist of dense masses of the fungus, having the distribution and appearance of caseous tuberculous nodules. Invasion of the blood-stream causing mycotic nodules in the liver, kidney and spleen has been described. Clinically, the disease is indistinguishable from chronic tuberculosis. Many authorities hold that the aspergillus infection is always secondary to the tubercle bacillus, even though the aspergillus predominates at the time of death. French writers state that the disease is to some extent occupational, being relatively common among pigeon-feeders and hair-combers; pigeons are fed by hand with rye grain and rye flour is used for removing grease from hair. Many kinds of seeds are contaminated with aspergillus spores but rye appears to harbour a fungus of virulent type.

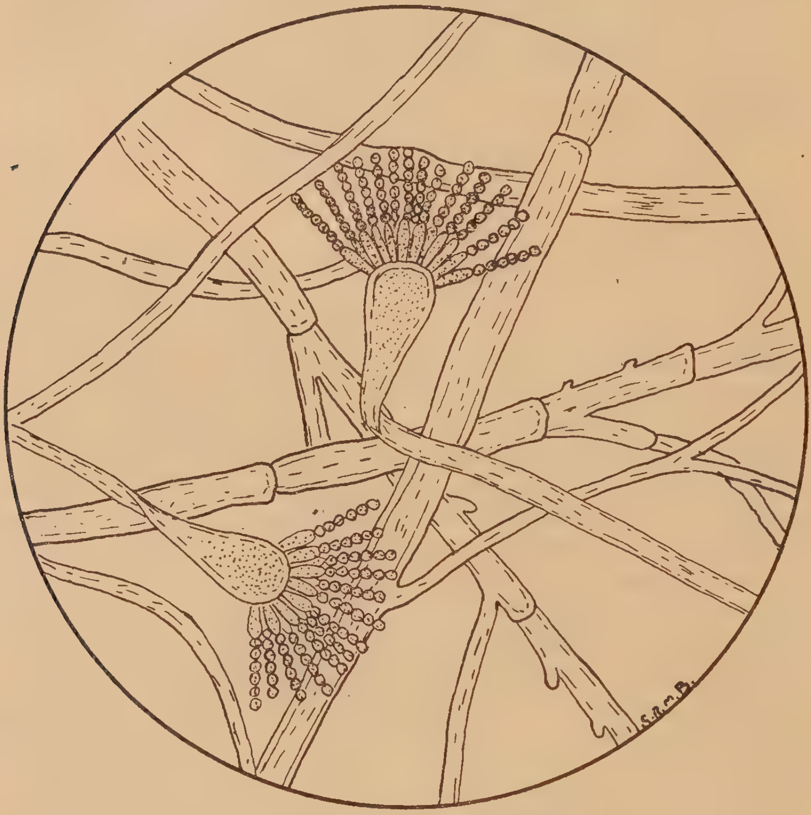

FIG. 37.—*Aspergillus fumigatus* × 400

Diagnosis

For diagnosis during life it is essential to identify the organism in the sputum and, more important, to assess the significance of a positive finding. Vast numbers of specimens of sputum contain aspergillus in small amount, but this indicates nothing more than stagnation of sputum in a small cavity; sometimes it indicates a stale sputum which has been retained. Sometimes, during the course of postural drainage for bronchiectasis a long-undrained cavity may yield a large amount of aspergillus. Primary aspergillosis can be diagnosed with confidence only when common disorders of the lung have been excluded, and when the sputum consistently contains masses of the fungus, most significantly in the form of definite colonies.

Recognition and culture of organism

Rénon recommended staining the sputum for ten minutes with safranin, which imparts an orange colour to the mycelium and spores. Cultures should be incubated at 37° C. for two days on Raulin's fluid medium. This consists of cane sugar 70 grams; tartaric acid 4 grams; ammonium nitrate 4 grams; ammonium phosphate 0·60 gram; potassium carbonate 0·60 gram; magnesium carbonate 0·40 gram; ammonium sulphate 0·25 gram; zinc sulphate 0·07 gram; ferrous sulphate 0·07 gram; potassium silicate 0·07 gram; water to 1,500 c.c. The materials should be dissolved by boiling and the solution filtered before being tubed and sterilized by steam at 100° C. Ordinary laboratory protein media are not as suitable as Raulin's medium. Pathogenicity may be tested on the pigeon; the bird is susceptible to intravenous inoculation and quickly develops pseudo-tuberculous lesions in the liver.

Aspergillosis in the ear and nose

Aspergillus has been found implanted on ulcerated surfaces in the ear and nose, giving rise to large colonies. Foreign bodies, beads in the ear or nose, or collections of inspissated blood or pus, may also form a nidus for implantation and give rise to pigmented otoliths and rhinoliths.

Aspergillosis of the skin

Contamination of superficial ulcers of the skin with the aspergillus is not infrequent in natives in the tropics where temperature conditions are ideal, and where cleanliness is not studied.

Treatment

Aspergillosis of the lung when well established is inevitably fatal. No specific treatment is available. For superficial lesions mercuric chloride (1 in 2,000) is the most effective antiseptic.

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ASPHYXIA

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1. ASPHYXIA DUE TO OXYGEN DEFICIENCY – 168
2. ASPHYXIA DUE TO RESPIRATORY DEFECTS – 169
3. ASPHYXIA DUE TO DISEASES OF THE LUNGS – 170
4. ASPHYXIA DUE TO FAULTS OF CIRCULATION – 171

Reference may also be made to the following titles:
ASPHYXIA IN CHILDREN   RESUSCITATION

108.] Asphyxia (literally pulseless) includes all conditions in which the gaseous exchange of the body is disturbed. A convenient subdivision into types, according to their causes, is as follows:

1.–ASPHYXIA DUE TO OXYGEN DEFICIENCY

Oxygen deficiency is met at heights where the barometric pressure is low, and in mines and sewers where oxygen is replaced by other gases.

A more important type of asphyxia is carbon monoxide poisoning, either by coal gas (a common form of suicide), or by exhaust gas from a petrol motor discharging into a closed space or leaking into a closed car.

Diagnosis The diagnosis of this group is usually obvious from circumstances. It is important to remember that, whereas in most forms of asphyxia there is cyanosis, in carbon monoxide poisoning there is not, because carboxyhaemoglobin is a cherry-red compound.

Treatment Treatment consists in the provision of ample oxygen combined with the use of respiratory stimulants, especially carbon dioxide, and artificial respiration in cases in which the respiratory centre is failing from the anoxaemia. For the latter purpose the Drinker apparatus is excellent, but there is a cheap and conveniently portable instrument available in the Bragg-Paul pulsator (Siebe Gorman) which may be hired for emergency use. These apparatus are described in the article on Resuscitation.

2.–ASPHYXIA DUE TO RESPIRATORY DEFECTS

The group of respiratory defects includes both obstructive and nervous interference with the act of breathing; obstruction may be caused by inflammatory or neoplastic swellings in the mouth, pharynx, larynx and trachea, by pressure on the trachea from swellings outside it, such as an enlarged thyroid or thoracic neoplasm, by paralysis and spasm of the vocal cords, or by paralysis of the muscles of respiration as in poliomyelitis.

Laryngeal diphtheria

Laryngeal diphtheria must also always be borne in mind as a cause of obstruction. In this condition the larynx moves up and down with each breath and there is recession of the lower ribs and interspaces. Constitutional signs are serious but there may be nothing to see in the throat. Swabbings should be taken and inquiry should be made for any similar cases in the neighbourhood.

Other causes of obstruction

Retropharyngeal abscess is an occasional cause of asphyxia, less rarely in infants than in adults (see p. 176). Oedema of the larynx may occur apart from inflammatory causes, in diseases causing oedema (e.g. renal disease and polycystic disease of the kidneys), in iodism, and in some allergic conditions such as angioneurotic oedema. It may occur as an early or late complication of irradiation treatment of carcinoma of the larynx and hypopharynx. More rarely a foreign body such as a denture may become impacted in the neighbourhood of the larynx. Tuberculosis or syphilis may be responsible. Backward displacement of the tongue has been known to cause acute asphyxia.

Pressure on the trachea may occur from malignant metastases in the lymphatic glands. Pressure within the thorax is usually shown in other ways also, such as oedema of the neck and arms or cyanosis.

Bronchial spasm

Bronchial spasm may cause asphyxia. Paroxysms of difficulty in breathing occur both in asthma and also in certain cardio-renal conditions, in which case they may be of the Cheyne-Stokes type. This, together with the changes in the retina, the urine and the arteries, may indicate the diagnosis. In bronchial asthma the history of the patient and of his family and the shape of his chest are more useful guides than the response to adrenaline, since this drug will often cut short attacks of both varieties.

Treatment

It is obviously of the first importance that any obstruction to respiration should be removed. When the obstruction is in or near the larynx it is a matter of judgement when intubation or tracheotomy must be performed. In diphtheria, tracheotomy was formerly a frequent operation; intubation has now taken its place. If there is any doubt about the diagnosis of diphtheria it is better to give serum at once. In Ludwig's angina and in acute suffocative laryngitis tracheotomy may be urgently necessary.

For allergic oedema of the glottis adrenaline (e.g. solution of adrenaline hydrochloride, 3 to 10 minims) should be given. In asthma adrenaline is indispensable and solution of adrenaline hydrochloride, 1 to 5 minims, should be given subcutaneously early in the attack and repeated at intervals. The high-pressure adrenaline spray is also of great value. In intervals between attacks ephedrine has a definite use. Prevention of attacks by removing the offending agent if this can be found, and by desensitization when this is possible, is better.

In iodide intolerance the correct treatment is to give 4 grams of sodium iodide intravenously. According to Snodgrass, this method and dosage were completely successful in 98 out of 99 cases. Increasing the oral dosage of iodide does not appear to have been successful in so high a proportion of cases.

Oxygen has its uses in some cases of tracheal obstruction, particularly in thyroid crises, post-operative or otherwise: the oxygen tent if available is most effective, otherwise the nasal catheter should be used.

In severe cases of laryngeal spasm, such as those associated with parathyroid disorder, injection of parathormone combined with administration of a calcium salt is indicated. Mediastinal tumours springing from the thymus or other lymphatic tissue are usually sensitive to irradiation. This treatment is also of value in Hodgkin's disease.

Nervous causes of asphyxia

Among the nervous causes of asphyxia are increased cerebral pressure, tetanus and poliomyelitis. Cases of the former are on record in which life has been saved by artificial respiration until decompression could be performed. Poliomyelitis may affect the respiratory muscles. In such conditions the Bragg-Paul pulsator (p. 168) finds its most important application.

(For the treatment of asphyxia by drowning, see DROWNING: RESUSCITATION.)

3.–ASPHYXIA DUE TO DISEASES OF THE LUNGS

Diseases of the lungs comparatively seldom produce asphyxia solely because the area for oxygenation is insufficient; the usual cause is venous short circuit. This means that the lung circulation continues through tissue which is inadequately ventilated. The blood as it leaves the lung is still venous and arriving in the left ventricle pollutes the oxygenated blood (i.e. arterial anoxaemia).

In many inflammatory conditions of the lungs the alveolar membrane becomes less pervious to the passage of oxygen. Oxygen therapy is based upon the fact that by increasing the pressure of oxygen the gas may be forced through to the venous blood. It is therefore in this group of diseases that oxygen is of most value.

Pneumonia

Lobar pneumonia is one of the commonest indications for the use of oxygen. It is equally of value in extensive broncho-pneumonia whether in children or adults. In influenzal pneumonia, when the blood-flow continues through the solid parts of the lung, oxygen cannot properly reach the short-circuiting venous blood and its value is therefore much less.

When asphyxia is due to causes such as pressure on the lung, the obvious indication is to reduce that pressure if possible. Spontaneous pneumothorax is an example. The onset of this condition should be suspected when a sudden pain in the side is followed by an increasing dyspnoea. A positive pressure is built up in the pleural cavity; this shifts the heart and mediastinum and interferes with the movements of the sound lung. The asphyxia thus produced may be severe enough to cause acute mental symptoms. The treatment is to allow the pressure to fall to atmospheric through a fine needle attached to a tube which opens under water. The needle may be left in position for hours at a time, or removed and re-inserted when necessary.

Spontaneous pneumothorax

If a pneumothorax does not produce asphyxia or great discomfort it should be left alone since any lung perforation is more likely to heal when the lung is contracted.

With massive pleural effusion the indications for removal (apart from diagnostic puncture) are the same, but it is usual to substitute air for some of the liquid in order to avoid a too rapid expansion of the collapsed lung. In both these conditions it may be necessary to continue a therapeutic pneumothorax if there is tuberculosis of the lung.

Pleural effusion

Asphyxia is easily produced by an attack of bronchitis in a case of emphysema because the surface area of the alveoli is reduced and the ventilation is poor from loss of elasticity. Oxygen is then indicated. Tuberculosis must be extensive before the gaseous exchange is interfered with because the morbid process closes the blood-vessels and prevents venous short circuit. Whenever pulmonary oedema is present oxygen therapy will be of benefit. The need for oxygen is not necessarily shown by, nor is it proportional to, the cyanosis present.

Other diseases

The use of carbon dioxide in lung inflammations is limited to those conditions in which the ventilation is inadequate and those in which it is necessary to open up collapsed areas. Attempts are being made to employ it more widely, so far with little success.

Acute pulmonary oedema is a dangerous though uncommon condition. It is accompanied by a frothy or even pink sputum. Immediate venesection or the use of morphine and atropine will sometimes save life.

4.–ASPHYXIA DUE TO FAULTS OF CIRCULATION

This group includes all those faults in the distribution of blood by the heart, blood-vessels and vasomotor nerves which cause asphyxia. They may be either general or local.

Any form of heart failure will give rise to some degree of asphyxia, either primarily through slowing of the circulation or secondarily by causing pulmonary oedema.

The commonest form of cardiac asphyxia is congestive heart failure, more often with changes of rhythm than without (auricular fibrillation). In the absence of lung oedema the peripheral arterial blood fails to show

Congestive heart failure

any diminution of oxygen or any increase of carbon dioxide. The cause of the dyspnoea is therefore thought to be central. It follows that the use of oxygen is of much less value than in lung diseases. Digitalis and morphine are the most useful drugs.

Heart-block

Convulsions as a result of asphyxia are seen in congenital morbus cordis and in heart-block. The latter is suspected when a pulse-rate of forty or less is found in an elderly person. The attacks of unconsciousness are sometimes accompanied by convulsions and may cease to occur once the steady idioventricular rhythm is well established.

Vasomotor disturbances

Vasovagal faints occur most commonly in highly-strung boys and girls about the age of puberty, especially when allowed to attend church services fasting. Some adults faint readily at the sight of blood or when they feel a sudden pain. The diagnosis usually does not present any difficulty (see also p. 642).

Aortic regurgitation is a cause of cardiac faints. It is suggested that the sudden fall of pressure in the coronary arteries is responsible. Coronary thrombosis is sometimes accompanied by signs of asphyxia.

Local asphyxia

The local forms of asphyxia include all types of arterial obstruction whether due to spasm (Raynaud's disease) or to organic block. Pain is a prominent symptom, especially in intermittent claudication; radiographs of the legs will often reveal extensive calcification, and the peripheral pulses may be weak or absent. Diabetes mellitus is one of the conditions commonly associated with arterial disease and often gives rise to gangrene.

For the separation of the different varieties of local asphyxia grouped under the term Raynaud's disease, and the effect of sympathectomy in this condition, see RAYNAUD'S PHENOMENON.

For the treatment of cardiac failure see HEART, and of gangrene due to local asphyxia see RAYNAUD'S PHENOMENON and ARTERIAL DISEASE AND DEGENERATION.

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ASPHYXIA IN CHILDREN

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Reference may also be made to the following titles:

ASPHYXIA   RESUSCITATION

109.] Many of the causes of asphyxia in childhood are not peculiar to the early years of life, although the details of treatment will vary according to the age of the patient. In considering the types of asphyxia seen especially during childhood, it will be convenient to divide them into two groups: (1) asphyxia during the early weeks of life; (2) asphyxia in childhood after the neonatal period. It is hardly necessary to point out that in every case a careful history should be sought, and the patient must be examined as thoroughly as circumstances permit. Special attention should be directed to the possibility that a foreign body has been inhaled, remembering that a radiograph of the chest will usually reveal an opaque object, or an inflammatory zone surrounding one which is irritative without being opaque.

Causes of asphyxia not dealt with in this section are as follows: pneumonia, pleural effusion, pneumothorax, asthma, massive collapse of the lung, capillary and membranous bronchitis, 'heliotrope' form of influenza, cardiac failure, whooping-cough, epilepsy and convulsive seizures.

1.–ASPHYXIA DURING THE EARLY WEEKS OF LIFE

'Blue' and 'white' babies

Two forms of asphyxia are usually described in new-born babies, namely asphyxia livida or cyanotica, and asphyxia pallida. It is not necessary to give a detailed account of the appearance and reactions of 'blue' and 'white' babies, but it must be clearly understood that whereas asphyxia livida indicates that pulmonary respiration has not become established, asphyxia pallida points not only to respiratory but also to vasomotor failure; it therefore resembles in many ways the condition known as 'surgical shock', in which collapse, fall of blood-pressure and cardiac weakness figure prominently. A 'blue baby' which is not recovering frequently passes into the state of white asphyxia before death; but white asphyxia may be due to causes which are not primarily respiratory, e.g. intracranial haemorrhage.

(1)—Causes

When a new-born child is seen to be asphyxiated, whether 'white' or 'blue', all the causes which may interfere with the establishment of pulmonary respiration must be considered.

(*a*) *Prematurity*

The premature infant's nervous system is not sufficiently developed to control and co-ordinate action of the respiratory muscles; this primary difficulty is increased by the softness of the chest-tissues, and sometimes by the added effect of intracranial trauma.

(*b*) *Birth trauma*

Respiratory birth trauma

During the birth process the child may inhale maternal blood or discharges, amniotic fluid or meconium. These cause obstruction of the air-channels, and if they are irritating may excite a secretion of fluid which adds to the obstruction.

Intracranial birth trauma

Damage to the intracranial contents during birth is a frequent cause of neonatal asphyxia. In the most severe cases the lesion is caused by haemorrhage, usually venous, which may be extradural, subdural, subarachnoid, cerebral or intraventricular. But haemorrhage is by no means an essential lesion; cerebral compression, contusion, congestion or oedema may cause respiratory distress by interfering with the nervous control of respiration, and one or more of these intracranial complications are very liable to occur if the intracranial dural septa (especially the tentorium cerebelli) are torn by moulding which is either extreme in degree or effected too rapidly.

(c) *Atelectasis*

Atelectasis

Failure of the lungs to expand may be due to a congenital malformation of the lungs or to enlargement of the thymus, but in some cases the cause is quite unknown.

(d) *Malformations*

Malformations

Examples of congenital anomalies which may cause asphyxia at or shortly after birth are laryngeal obstruction (papilloma or web), congenital laryngeal stridor, cystic disease of the lungs, diaphragmatic hernia, foetal ascites, intrathoracic cysts, and congenital cardiac deformity.

Congenital laryngeal stridor is due to partial blockage of the larynx by indrawing of the aryteno-epiglottidean folds during inspiration. It causes inspiratory stridor which increases during sucking and crying and may be severe enough to produce definite asphyxia. Usually the infant's general condition remains quite satisfactory and this fact helps to establish the diagnosis.

(e) *Overlying*

Overlying

This is a very infrequent cause, but it must be mentioned because of its special medico-legal significance. For a similar reason the possibilities of foul play, especially when the infant is illegitimate, must be reviewed.

(f) *Miscellaneous Causes*

A miscellaneous group of conditions which may be associated with asphyxia, often with cyanosis, in babies subsequent to the second or third day after birth includes rhinitis and pharyngitis, septicaemia, pyelitis and icterus gravis.

(2)—Treatment

(a) *Of Asphyxia Livida*

The baby should be covered by a warm blanket, and his air-ways should be cleared by gently swabbing out the mouth and by suction of any obstructing fluid or discharges from the pharynx, using a soft rubber or gum-elastic catheter. The re-accumulation of secretion may be lessened by a hypodermic injection of atropine sulphate $\frac{1}{1000}$ grain. Breathing may be encouraged by one of the methods of artificial respiration, e.g. Sylvester's or Buist's, provided that the technique is applied with care and gentleness. Schultze's method should not be used. It is often sufficient to stimulate the baby's skin by rubbing the spine with a warm towel or by alternate baths in hot and tepid water. The inhalation of oxygen with 7 per cent carbon dioxide through a nasal catheter is of value not only as a stimulant to pulmonary respiration but also as a means of ensuring that the lungs become fully expanded.

Drugs

The following are sometimes of assistance: lobeline hydrochloride 1 to 3 mg. subcutaneously; coramine 1 c.c. intramuscularly; caffeine and sodium benzoate 1 grain subcutaneously.

(*b*) *Of Asphyxia Pallida*

The infant must be kept warm by blankets and covered hot bottles. His air-ways should be cleared of obstructing secretions, and the use of oxygen with 7 per cent carbon dioxide through a nasal or intratracheal catheter is clearly indicated. The child is in a state of surgical shock and must be handled with the greatest care.

Stimulants worthy of trial are strychnine hydrochloride, $\frac{1}{300}$ grain subcutaneously; cardiazol, 0·5 c.c. intramuscularly; camphor in olive oil (10 per cent), 5 to 10 minims subcutaneously.

(*c*) *Special Indications for Treatment*

Prematurity and intracranial birth-trauma.—Prophylaxis by education of the public and by careful obstetrical practice is most important. When damage has occurred the child should be treated with at least as much gentleness as the adult suffering with a fractured skull. He must be shielded from strong light and only the more gentle methods of artificial respiration are permissible. Rectal injections of a 5 per cent solution of common salt, roughly 1 teaspoonful in 2 ounces of water, given 4-hourly, may help to lower an increase of intracranial tension and so diminish asphyxia. A mixture containing chloral hydrate and potassium bromide, 1 grain of each, given hourly by the mouth allays restlessness and controls convulsions.

Atelectasis.—Inhalations of oxygen with 7 per cent carbon dioxide should be given for ¼ hour every two hours for several days in order to stimulate expansion of the lungs. X-ray treatment is said to be beneficial when the thymus is enlarged, but it should be employed with caution.

Malformations.—Many of these are disappointing from the therapeutic point of view, but the opportunity for dealing surgically with a laryngeal web or papilloma should not be missed. Congenital laryngeal stridor gradually disappears spontaneously, and is not amenable to treatment.

2.—ASPHYXIA IN CHILDHOOD AFTER THE NEONATAL PERIOD

Retropharyngeal abscess

Retropharyngeal abscess is comparatively common in infants between the age of nine months and three years and is usually secondary to an acute pharyngitis. A red fluctuating swelling appears in the pharynx, at one or other side of the mid-line, and the child looks extremely ill and shows dyspnoea and dysphagia. Immediate incision is required and great care should be taken to avoid the inspiration of pus and blood into the lower air-ways.

A rarer type of retropharyngeal abscess occurs between the cervical vertebrae and the prevertebral fascia; it is secondary to disease of the vertebrae, usually tuberculous. The swelling is often in the mid-line of the pharynx, and its development is not so rapid as in the form consequent upon acute pharyngitis. The child's neck is usually rigid and an X-ray shows disease of the bones. This abscess should never be opened by incision of the pharynx; when drainage is necessary it should be performed through the neck, posterior to the sternomastoid muscle.

Laryngitis

Young children are very liable to various forms of laryngitis, any of which may cause asphyxia. Frequently the patient's cry is hoarse, the voice is impaired or lost and cough is troublesome. It is of great practical importance to consider the possibility of diphtheritic (membranous) laryngitis in every case; sometimes the laryngitis indicates the onset of measles or whooping-cough.

'Croup'

Laryngitis stridulosa or 'croup' is a spasmodic closure of the larynx met with in children between two and five years of age; it generally occurs during the night and causes the child to awake in a state of terror with a brassy cough, stridor, great dyspnoea and often marked cyanosis. The attacks may recur several times in a night, and on several nights in succession; during the day the patient often appears to be comparatively well except that he has a cold in the nose and throat and is slightly hoarse. Treatment consists in giving 2 to 5 grains of sodium bromide at bedtime, or ¼ to ½ grain of phenobarbitone (luminal) and the application of hot sponges to the neck when the attack occurs.

Laryngismus stridulus

Laryngismus stridulus is usually a manifestation of tetany and is seen especially in rachitic infants between the ages of three months and two years. Annoyance or excitement causes inspiratory distress which lasts a few seconds and terminates in a prolonged crowing inspiration. Other signs of tetany should be sought, e.g. facial irritability and carpopedal spasm. The treatment is directed chiefly to the cure of rickets, but the distressing attacks of laryngismus may be relieved by calcium chloride 20 grains thrice daily by the mouth in milk. Urgent cases may require intramuscular or intravenous injections of calcium gluconate (10 per cent), 10 c.c. every four hours.

Nervous factors

Young children of nervous and self-willed type sometimes cause great anxiety by their 'breath-holding attacks' or 'kinks' in which respiration ceases after full inspiration, cyanosis develops, and occasionally a convulsive seizure occurs. The attacks are usually due to a nervous outburst resulting from disappointment, anger or some other emotion; they are very rare in children subject to normal discipline and management, but occur rather in those of pampered upbringing. Treatment must be on general lines, to secure proper management by sympathetic but firm control. Sodium bromide may be useful temporarily.

Intrathoracic lesions

Occasionally severe intrathoracic lesions, such as enlargement of the mediastinal glands (tuberculosis, Hodgkin's disease, sarcoma, syphilis and whooping-cough), mediastinal cyst or abscess, or new growths, may cause asphyxia, mainly by pressure on the trachea or bronchi. The diagnosis must be made on general lines, by the history, clinical examination and radiography. Treatment will depend on the cause.

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ASTHMA

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Reference may also be made to the following title:

ALLERGY

1.–DEFINITION

110.] The term asthma (ἄσθμα, ‘panting’) is applied specifically to a type of dyspnoea caused by spasmodic constriction of the musculature of the bronchi. It is fundamentally paroxysmal in nature and principally affects expiration. It belongs to a group of diseases, commonly known as ‘allergic’, which includes hay-fever, eczema, urticaria and migraine (see article ALLERGY, Vol. I, p. 302). These conditions are quite likely to occur in an asthmatic as well as in other members of his family, and are generally excited by an abnormal hypersensitivity to some foreign substance, usually a protein; frequently there is a psychical, nasal, toxic, endocrine, or dietary disposing factor.

2.–AETIOLOGY

Hereditary tendencies

The tendency to develop allergic diseases runs predominantly in certain families; it is also more prevalent among white than among coloured peoples. Transmission through the mother is twice as frequent as through the father.

Age incidence

A third of all cases of asthma begin during the first decade, and in one of every four cases the onset dates from the first year.

Sex incidence

Among asthmatic children there is a nearly three to one preponderance of males. From the time of puberty to the menopause a slight preponderance of females is noted, and in old age there is again a slight preponderance of males.

It is only in a minority of cases that an hereditary tendency cannot be determined, and in these there is usually a history of a severe illness shortly before the onset of the allergic manifestation. In asthmatic children it is often a pneumonia complicating an infectious disease, such as whooping cough or measles; in adults influenza, pneumonia, or a severe bronchitis plays a similar part. In some cases an allergic hereditary predisposition and some severe tissue damage appear to be associated.

(1)—Specific Sensitization

Sensitization

The most important factor in initiating each attack is some specific sensitization. The specific sensitizing substance (‘allergen’) may be absorbed by inhalation (animal emanations, dusts, pollens, moulds and fungi), ingestion (foods and drugs), injection (serums, drugs, bites and stings), infection (bacteria and worms), or by contact (fabrics, chemical or physical agents). On absorption these are carried by the blood or lymph to the reacting organ.

The commonest sensitization is to some article in the environment or diet. Food is seldom the sole cause of asthma unless the spasms have originated during the first decade, or are accompanied by skin lesions.

An uncomplicated case of asthma commencing after childhood is most probably due to sensitization to an inhalant. In a non-seasonal case the four commonest causes are feathers, dust, animal hairs and orris root; in seasonal cases pollens also play a part.

Food

Food may affect the asthmatic in one of four ways. First, it may contain an article to which the patient is specifically sensitive at all times, in which event the patient generally knows what foods to avoid. Secondly, the patient may be specifically sensitive to the food when his power of digestion is impaired; quite a large number of asthmatics, especially children, who are more commonly food-sensitive than adults, show a diminished secretion of acid gastric juice or evidences of mucous gastritis, and thus improperly digested foods gain easier access to the blood-stream and hence produce reactions. Thirdly, since the stomach and upper intestinal tract are supplied by the vagus nerve, gastric distension may irritate the vagus and so set up a reflex bronchial spasm. Fourthly, certain articles of diet are more constipating than others and may necessitate the use of aperients which in turn lead to further vagal irritation.

Infections

Various infective conditions have been regarded as aetiological factors, and focal infections of the teeth, tonsils, gall-bladder, appendix, and other organs have been incriminated.

Bacterial allergy plays very little part in the majority of patients; even in cases which always commence with coryza the bacteria merely lower the resistance of the upper respiratory tract and so facilitate the absorption of the common inhalant sensitizing substances, especially if the patient is confined to the house or put to bed.

(2)—Non-Specific Factors

When there is gross sensitivity, each contact, however slight, leads to a reaction; but in less sensitive individuals the body may avoid or overcome the tendency to react. It is in this latter group with intervals of comparative freedom that non-specific factors become important. If, during exposure to the specific sensitizing substance, the resistance of the body is lowered by any of a group of non-specific, non-allergenic factors whether psychic, endocrine, nasal, toxic, dietetic or environmental, the reaction will ensue. These factors may be compared with catalysts which hasten chemical reactions, and help to explain why a person only becomes asthmatic with a cold, during states of emotion or excitement, after exertion, following dietary indiscretions or in certain atmospheres.

Psychic factors

Prolonged fear and emotions may precipitate allergic responses by disturbing the vago-sympathetic balance or decreasing the normal secretion of adrenaline. Sudden emotions may have the opposite effect of stopping reactions, acting through a similar mechanism. Most available evidence suggests that these psychic states can provoke allergic responses only in persons who are already allergic. Most of the psychological reactions reported, similar to that of the picture of the hay-field or the artificial rose causing hay-asthma, occur only in people who are known to be sensitive to the real articles; it is impossible to give a normal person hay-fever by getting him to smell an artificial rose, or even a real one. As the result of his allergy the symptoms have become a conditioned reflex which, after repeated exposures, is capable of being fired off solely through nervous channels without the intervention of the specific sensitizing substance. When, as the result of desensitization against the primary cause of the reactions, the patient is shown that he can be exposed to the original cause without reaction, all the psychic elements disappear, especially expectation, and the case becomes entirely allergic. This statement is proved by the fact that it is possible to prepare serum from a sufferer and inject it into the skin of a normal person. If this site is tested a local positive reaction will occur only with the specific substance to which the patient is sensitive (Prausnitz-Küstner reaction). This fact is difficult to explain on an entirely psychopathic basis.

Endocrine factors

Endocrine dysplasias have been regarded as disposing factors in asthmatic attacks, but there is no established proof of dysfunction in any of the ductless glands in asthmatics. Records of remarkable responses to endocrine therapy are few, and statistics show that endocrine dysfunction is rare in definite cases of allergy and allergic responses are very rare amongst patients manifesting endocrine dysplasias. Nevertheless it is known that menstruation, marriage, and the menopause play an important part in females, allergic states being worse at the onset of the menstrual periods, whereas during pregnancy there is a comparative freedom from symptoms. Estimations of the basal metabolic rate have shown this to be subnormal in most allergic conditions.

3.–MORBID ANATOMY

It is extremely rare for death to take place during an attack in an uncomplicated case of asthma. The records of necropsies on those dead from asthma do not show any unanimity in the findings to prove whether death has been brought about by (*a*) the spasm of the bronchial muscle, (*b*) the occlusion of the lumen by oedema of the mucous membrane and the presence of exudative products, or (*c*) inhibition of cardiac action by the vagotonic mechanism.

Local morbid changes

The local morbid changes reported include thickening and hyalinization of the basement membrane with hypertrophy of the bronchial musculature; it is suggested that when these changes predominate, they are the result of the repeated spasms of the musculature; but their degree has not been found proportionate to the duration or severity of the disease. Other changes include hypertrophy, metaplasia, and sacculation of the epithelial layer of the bronchi. The infoldings of the epithelium and the exudative products of the hyperplastic bronchial mucous glands support the occlusive theory. Some cases show more muscular than epithelial changes, whereas the reverse is the case in others, but in practically all cases there is in the tissues of the bronchi an eosinophilia which may spread even to the peribronchial structures and the bronchial lymphatic glands.

In long-standing cases changes occur in the lungs, the thorax and its muscular attachments, and in the cardiovascular system.

Over-distension of the lungs

The over-distension of the lungs is due to the difficulty in deflation, caused by muscular spasm and occlusion of the lumen of the bronchi. At first this over-distension of the lungs is limited to the attack, and the normal contour is restored soon after the attack subsides, but after frequent paroxysms the distension becomes permanent. It is only in very long-standing cases in which repeated coughing and straining against the obstruction occur that pulmonary atrophy of the alveoli and their rupture may lead to the production of the pathological state known as emphysema. Chronic bronchitis and atelectatic changes may also occur.

Emphysema

Thoracic deformities

The thoracic deformities commonly found include kyphosis of the upper spine, increase in the antero-posterior diameter of the upper chest, pigeon-breast or the occasional indrawing and depression of the cartilaginous portions of the lower fixed ribs, and lifting of the clavicles.

Changes in muscles

Such thoracic deformities are accompanied by changes in the muscular attachments from the chest to the spine and head, as a result of which the muscles develop a new length and tone, and so, by fixing the chest in the expanded position, tend to augment the deformities.

Cardiovascular changes resulting from prolonged asthma are described by some investigators, but denied by most. The change most frequently found is hypertrophy of the right ventricle.

4.–BACTERIOLOGY

Sputum

The early investigators of the sputum were attracted by the Curschmann's spirals, Charcot-Leyden crystals and Laennec's 'perles'; more recent workers have investigated the bacteriological aspect. In normal sputa the order of relative frequency of the bacteria present is staphylococci, pneumococci, streptococci, *M. catarrhalis*; in asthmatic sputa it is streptococci, *M. catarrhalis*, pneumococci, staphylococci. In eosinophilic sputa Gram-negative bacilli can usually be cultured from the spirals and it has been suggested that they may cause spasm of the bronchi by direct stimulation of the muscle through the histamine-like substances which they can produce. There is no definite proof that a true allergic reaction occurs from sensitization to bacterial products. Recent statistics show that the use of stock vaccines or autogenous vaccines in the treatment of asthma has very little to recommend it, unless they are regarded as effecting non-specific reactions. No appreciable differences in the benefits of treatment were observed whether stock vaccines were used or autogenous vaccines which contained (i) only the organisms which could be considered pathogenic,

(ii) all the organisms present, and (iii) all pathogenic and normal inhabitants which gave positive skin reactions.

Nose and sinuses

Enlargement and swelling of the nasal mucosa, with subsequent infection, are now considered to be more often a result of repeated allergic reactions than a cause. The bacteria most frequently isolated are staphylococci, streptococci, diphtheroids and pneumococci, in that order.

Faeces

No appreciable differences have been found between the intestinal flora of asthmatics and normal persons.

5.–CLINICAL PICTURE

There are many essential differences between the types of asthmatic attack that occur in infants and children and those in adults. Nevertheless, the clinical picture of the actual spasm is fairly constant, and was vividly described by Hyde Salter (1860), himself a sufferer.

Hyde Salter's description

> With a face expressive of the intensest anxiety, unable to move, speak, or even make signs, the chest distended and fixed, the head thrown back between the elevated shoulders, the muscles of respiration rigid and tightened like cords, and tugging and straining for every breath that is drawn, the surface pallid or livid, cold and sweating—such are the signs by which this dreadful suffering manifests itself. . . . To be fairly imagined it should be witnessed—to be fully appreciated it should be experienced.

Asthma shows a definite predilection for the early hours of the morning, but in children the attacks generally occur before midnight at first and in many cases during the day. Once a definite hour is established it tends to remain constant. Some patients are free from symptoms by the sea, others inland; some are well in large, smoky cities, others require country air for relief. Some require pine woods, others the open spaces; some hilly country, some flat. Asthmatic symptoms do not usually occur above an altitude of 4,000 feet, and the majority of patients obtain immediate relief on entering a hospital or convalescent home. Week-end periodicity is marked in a third of the cases, and in others there is a great tendency for an alternation of allergic manifestations. In some cases skin conditions and sick headaches co-exist with the asthma, in others they alternate, and in still others no definite relationship can be deduced. Most asthmatic individuals are particularly free from other ill-health and above normal mentally.

(1)—Types in Childhood

(*a*) *Acute Bronchitic Type of Infancy*

The early manifestations of asthma in infancy are often obscure because they are associated with so much catarrh. The clinical picture is that of a bronchitis of the smaller tubes coming on with great suddenness. Dyspnoea is frequently the first symptom, although paroxysmal sneezing may usher in the catarrhal stage. There may be a slight rise in temperature with acceleration of the respiratory rate. Cough may develop later and become persistent and, together with the cyanosis and prostration, present an alarming sight resembling that of severe pneumonia. On auscultation, expiration is prolonged, and accompanied by sibilant and sonorous râles and, as the condition progresses, the catarrh completely overshadows the element of spasm. The symptoms may be of brief duration or a typical bronchitic course may be pursued and hardly be completed before the next bout begins. *Auscultation*

(*b*) *The Hereditary Type*

This type frequently occurs in blond children, mostly boys, and in three out of every four cases the asthma commences before the third year. It is intimately related to eczema commencing in the early months of life. The attack usually begins suddenly at night, the victim waking with a stuffy suffocative feeling. He sits up, braces his shoulders, and clings to the back of the bed or to a parent for support in his respiratory efforts. The pulse is rapid, the respiratory rate increased, and the temperature normal or slightly raised. Dyspnoea is intense with little or no cough. The chief difficulty is in expiration, the chest remaining indefinitely in the position of full inspiration, and the expiratory muscles making strenuous efforts to empty the air from it. There is no period of rest between the prolonged expiratory phase and the beginning of inspiration. The wheeze is quite audible from afar. On inspection, the alae nasi are expanded, and the face pale or dusky with an extremely anxious look. Well-marked retraction of the soft parts, the supraclavicular spaces and the epigastrium, the very slight expansile movement of the chest, and the over-distension of the upper part are striking. There is rarely any accompanying bronchitis. *Inspection*

Auscultation On auscultation there are practically no inspiratory sounds to be heard, but wheezing, whistling expiratory rhonchi are found everywhere. As the attack subsides expiratory and inspiratory rhonchi appear. Sputum is rare, but if obtained is clear and viscid. X-ray examination of the chest does not show any gross pathological alteration, although sometimes there is an increase in the shadows at the hilum or a slight peribronchial fibrosis. The Mantoux tuberculin reaction is rarely positive, and the fractional gastric analysis commonly shows well-marked hypochlorhydria. Periodicity, with complete cessation between the spasms, is characteristic of these attacks, but in younger children a constant wheeze is often found.

(*c*) *The Eczema-Prurigo-Asthma Syndrome*

In its common characteristics this syndrome is a variant of the above type. From a few months of age the affected child has a facial eczema which lasts from one to two years, during which time the eczema spreads gradually to the rest of the body. As the lesions on the face clear, they reappear mostly in the flexures of the limbs, round the wrists and at the back of the neck, where lichenification is induced by excessive scratching. In a large percentage of cases wheeziness develops at from two to five years of age, and later severe asthmatic attacks accompany or alternate with exacerbations of the prurigo.

(*d*) *The Lung-Damage Type*

Clinical picture

This type takes the form of a bronchitis with superadded spasm, and is uncommon before the age of five years. A respiratory infection or exanthem is usually the starting point, and each subsequent attack or series of attacks is preceded for twenty-four hours or more by coryza, an inflamed throat, sneezing attacks or bronchitis. It occurs mainly in the winter months when naso-bronchial affections are prevalent. Familial transmission is difficult to determine, and other allergic manifestations in the individual sufferer are extremely unusual. Boys and girls are equally susceptible to this type. The 'recurrent bronchitis' of young children, with low fever and sibilant râles is probably a milder form of this type of asthma.

The onset of the asthma takes the form of frequent coughing spells of varying duration and frequency, and it is this cough which becomes the persistent and disturbing feature. Fever is present but is generally slight. The dyspnoea commonly begins from twenty-four to forty-eight hours after the cough, and is not so purely expiratory as the adult type, inspiratory difficulty occurring as well. There is evidence of abundant secretion, but it is rare for young children to expectorate it. The condition tends to pass into chronic bronchitis, with more or less constant wheezing, and there is often well-marked distress with cyanosis, restlessness, and orthopnoea.

Percussion

Auscultation

Percussion shows an exaggerated resonance, and the pulmonary distension is shown by an extension of the tympanitic note downwards beyond the normal limits at the bases. On auscultation, expiration is prolonged and accompanied by sibilant and whistling rhonchi all over the chest, to which moist sounds are added, especially at the bases.

The duration is often transient, the attack terminating in relief by vomiting a large amount of mucus; or the attack may last for weeks, the rhonchi tending to remain constant. Relapses are frequent. Gross fibrotic and bronchiectatic changes can commonly be seen in the radiograms of the chest, the Mantoux reaction is frequently positive, and gastric acidity is normal.

(*e*) *Coryzal Asthma*

Conjunctivitis, itching of the nose and eyes, profuse watery nasal discharge, frequent violent sneezing, complete nasal blockage, lachrymation, and photophobia may precede a definite wheeziness. These symptoms may be seasonal, occurring during the warmer months and brought about by a special sensitivity to pollens. In other cases attacks occur throughout the year without marked variation, and are then due to a hypersensitiveness to some animal emanation, often from a pet, or to feather fillings of pillows or bedding, or to dust. Other cases combine the two types.

(2)—Types in Adults

Many classifications of the types of asthma met with in adults have been suggested. The great majority of these are based upon the aetiological factors concerned, and describe the animal emanation, food, pollen, drug, and bacterial types; others refer to the gross symptoms and divide asthma into the wet and dry types; others, according to the build of the patient, describing thin and obese types; and in some cases a special exciting factor is suggested, such as the menstrual, aspirin-sensitive, or occupational types. But the aetiology is as a rule multiple, and the majority of cases embody several types. A clinical classification depending upon whether there are clear-cut paroxysms with definite free intervals, or whether the symptoms are constantly present, is therefore preferable; it is as follows:

(*a*) *Cases with Alternating Paroxysms and Free Intervals*

Infrequent attacks

Infrequent attacks occur after contact with some occasional or seasonal sensitizer, whether food, pollen, epidermal or bacterial, e.g. the wheezy turns that sometimes complicate hay fever or a cold. There may be a prodromal sneezing, but cough and sputum are generally absent during the attack, although both may occur slightly at its termination. The complaint is generally of a mild dyspnoea with a 'musical chest', and the clinical signs are a mild bronchial spasm with rhonchi heard evenly over the chest. There is rarely any degree of incapacity.

Frequent attacks

Frequent attacks are generally due to the continued operation of some specific allergens. Often the onset of the first paroxysm is assigned to an attack of influenza or pneumonia which was rather slow in resolving.

(*b*) *Cases with Constant Symptoms and without Free Intervals*

Constant wheezing may be present for many years without leading to any evidences of definite pathological changes in the lungs, but many patients show chronic pulmonary inflammation and distension.

Without pulmonary inflammation

Cases without chronic pulmonary inflammation occur. Most of these patients suffer from poor health, indigestion and lassitude. Their asthmatic symptoms may be mild, moderate, severe, or intractable. The majority of the more severe cases have had many nasal and sinus operations and have learnt to take adrenaline in heroic doses daily. They are usually of 'lean and hungry look', with rapid hearts and low blood-pressures, with a continual wheeze audible from afar, and intensified by the least excitement or exertion. Shortness of breath is the main symptom, cough is relatively unimportant, and sputum is scanty, thin and watery, or absent. The chest is full of musical rhonchi, and expiration prolonged and high-pitched. Although the signs are commonly uniform over the chest, the affected areas may be patchy and change from day to day.

With pulmonary inflammation

Cases with chronic pulmonary inflammation and distension present a definite picture. The majority of patients of this type are plethoric individuals who have suffered from asthma practically all their lives; they have hyper-resonant, barrel-shaped chests, stooping shoulders and raised clavicles; an infective element may predominate. They complain of a constant dyspnoea, and towards daybreak they are troubled by a hacking cough which intensifies the dyspnoea. After a coughing bout an abundance of thick tenacious sputum is expectorated. Although the sufferers appear plethoric the blood-pressure is rarely excessive, except in elderly women. The coarse bubbling râles are more pronounced in the winter months.

Rare cases of this type commence spontaneously in later life, and in them the pulmonary distension predominates and the infective element is absent or slight. These patients are generally thin, not plethoric, with slightly barrel-shaped chests and raised shoulders. Their chief complaint is shortness of breath with moderate cough and not much sputum.

6.–COURSE AND PROGNOSIS

Age

Sex

Complications

Many asthmatics 'pant on to good old age'. The conditions which influence the prognosis are: (1) The age at onset. Many children, especially boys, tend to improve towards puberty, but in girls this is less obvious and other manifestations of allergy often arise. Most cases of 'status asthmaticus' occur in patients whose asthma has commenced rather late in life. (2) Sex. Women who have asthma for the first time at puberty or marriage and whose attacks are related to menstruation will probably find freedom at the menopause. (3) Family history. When other cases occur in a family, medical advice is sought much sooner and greater pains are taken to eradicate the tendency than in isolated cases, and the prognosis is thus much improved. Successful treatment does not appear to influence the tendency to transmit the allergic diathesis to future generations. (4) The attacks. The shorter the duration of the disease and the length of the attacks, the better the prognosis. The greater the frequency and the less complete the recovery between attacks, the worse the prognosis. (5) Complications. The greater the number of complicating allergic conditions, the worse the prognosis. Cases without any gross lung damage are more amenable to treatment. All varieties of malformed chests in children have a strong tendency to improve with age provided the original cause has ceased to act.

7.–DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

During attacks

During attacks many points are characteristic of the asthmatic spasm; the time of onset is commonly in the early hours of the morning, the posture of the patient stooping with a bracing of the shoulders. Inspection reveals the distended neck veins and prominence of the neck muscles during the deliberate attempts at inspiration. Percussion elicits a hyperresonance of the chest, and auscultation a difficult prolonged expiration, wheezing, sibilant and sonorous rhonchi, and later there are secretory changes.

In the free interval

In the free interval it is often necessary to rely entirely on the patient's history, so the elicitation of the following points is of the greatest assistance: the type of the attack, and frequent nocturnal and week-end periodicity; the age at onset; a family history of allergic manifestations in immediate relatives; a previous history of eczema or prurigo, nettle-rash, food-upsets, or recurrent attacks of 'bronchitis' or 'pneumonia'; the relationship of some illness to the onset of symptoms; the frequent association of itching skin affections, food-upsets, sick headaches, sneezing attacks, stuffiness in the head, hard, dry, unproductive cough, and 'wet noses' with the allergic state; eosinophilia both in the blood and at the site of the reaction; the characteristic sputum with Curschmann's spirals and eosinophils; the therapeutic test, the response to the administration of adrenaline or ephedrine; positive skin reactions.

Skin tests

By a careful history alone or elimination diets it is often possible to discover the association of a specific sensitivity, but a positive skin reaction to the suspected article is important additional confirmatory evidence. Skin tests are based upon the fact that certain substances when inhaled, ingested or taken into the body by other means are capable of producing allergic responses, and will produce an urticarial wheal when brought into contact with the lower layers of the epidermis, or give a congestive reaction if applied to mucous membranes. Skin tests may be performed by applying solutions of the specific allergens to the skin (patch test), to a series of scratches (dermal test) or by injection into the skin (intradermal test). Application of the solution to mucous membranes may be made to the eye (conjunctival test), the nose (nasal test), the mouth, or may even be instilled rectally. The dermal, intradermal and ophthalmic sites are those most commonly chosen. Positive reactions resemble urticarial wheals, appear in seven to ten minutes or sooner, are at their maximum in about fifteen to twenty minutes, and fade rapidly in half an hour.

Differential diagnosis

The chief difficulties of diagnosis are in differentiating asthma from the 'common cold', the dyspnoea of cardiac or renal disease, the recurrent bronchitis of children, and the severe bronchitis of old age. But in none of these morbid conditions does the dyspnoea have the same prolonged, difficult, expiratory, wheezing character that is so characteristic of asthma.

From the common cold

Great difficulty is frequently experienced in differentiating the 'allergic' from the 'infectious' cold. The allergic types are frequently recurrent, not contagious, nor related to exposure to another case; the visible mucous membranes are pale, glistening and oedematous unless they have been secondarily infected; the discharge is thin and mucoid, and smears may show eosinophils. The infectious type is definitely contagious and related to exposure to another case. The visible mucous membranes are hyperaemic, the discharge muco-purulent and neutrophils predominate.

From cardiac dyspnoea

Cardiac dyspnoea is intimately associated with muscular effort, is of an accelerated inspiratory gasping or panting nature, and is worse in the recumbent position. There is generally a high blood-pressure or evidence of heart disease, both of which are usually absent in asthma. Renal dyspnoea is usually accompanied by a high blood-pressure, a hypertrophied heart, arteriosclerosis, albuminuria and retinal changes.

From renal dyspnoea

From bronchitis

In asthmatic children the catarrhal element frequently overshadows any element of spasm and the early attacks of asthma in a child are generally labelled 'recurrent or chronic bronchitis' until finally a typical spasm occurs. In the chronic bronchitis of old age there are not the typical sudden attacks of fighting for breath but rather difficulty in inspiration due to its interruption by cough and the expectoration of a considerable amount of sputum. In children other conditions which must be differentiated are papilloma or diphtheria of the larynx, congenital laryngeal stridor, laryngismus stridulus, thymic dyspnoea and retropharyngeal abscess. Enlarged lymph glands and foreign bodies may lead to dyspnoea at any age. In adults the tachypnoea of hysterical subjects, the difficult breathing associated with chronic pulmonary tuberculosis, pulmonary new growths, and pathological states of the pleura and aneurysm, and in advanced age the low type of pneumonia must all be considered.

From other conditions

8.–TREATMENT

(1)—Prevention of Attacks

The preventive treatment of asthma necessitates the thorough elucidation of all the causes of the attacks. In each patient two groups of factors need detailed consideration, first the specific sensitizing substances, and second the non-specific catalyzing factors that tend to fire off any case.

In practically all cases of asthma in the earlier stages contact with a specific substance has originated the attacks. In determining the specific cause a careful history, skin reactions, and elimination diets play a most important part. Most asthmatics when tested with potent solutions by the intradermal method will react to one or more of these tests; it is therefore wise to remove these irritants as far as possible. Feather or down pillows, eiderdowns or bolsters, and feather, down, horsehair or rabbit-hair mattresses should be replaced by a rubber mattress and pillow, and the best Java kapok bolster and quilt. Only cosmetics free from orris root should be used. To avoid dust a minimum of ledges and furniture in the bedroom is essential, and electric vacuum cleaning is advisable.

Removal of irritants

Removal of predisposing factors

If, in those cases which always commence with a cold, the specific sensitizing substance is removed or the patient desensitized, further colds may arise without the patient developing any asthmatic symptoms. By giving vaccines, whether stock or autogenous, a temporary immunity to colds may be established and so the asthmatic spasms may be prevented, but the more permanent measure is to remove the specific sensitizing substance.

Food

The commonest foods that cause allergic reactions are wheat, egg, milk, chocolate, beans, potato, pig products and beef, in that order of frequency, and a basic diet can be devised avoiding these articles if proper skin tests are not available to determine the actual causes. The patient is placed on such a diet until free from symptoms, then one of the excluded foods is added each few days until symptoms recur, when generally the latest addition is the causative food. But this does not mean that it is the sole food, for patients are generally multi-sensitive; the process must therefore be continued until all the excluded foods are reintroduced except those that lead to reactions.

Hypochlorhydria

As the commonest cause of indigestion in an asthmatic is a deficient secretion of hydrochloric acid, this should be rectified. To prevent gastric distension three small, easily digested, simply compounded meals a day are best. A good early breakfast, a substantial hot midday meat meal, and a light, early supper several hours before retiring should be the rule. No food or drink should be taken after supper, and especially not just before or after getting into bed. If aperients are necessary they should be of the early morning saline variety as any slowly acting type taken at night causes vagal irritation at a time when the patient is most likely to have an attack.

Desensitization

Desensitization is necessary in cases in which the specific cause cannot be avoided or removed, and the methods employed may be either specific, directed against the definite causative allergens, or non-specific.

Specific desensitization

Desensitization to a specific food may be brought about by the ingestion of gradually increasing doses of a food, or by denaturizing the food to a large extent by the employment of heat or chemicals. Desensitization can be effected by injection of the specific factors of an inhalant nature. Patients are usually sensitive to more than one inhalant allergen if their symptoms have lasted for any length of time, and treatment with animal hairs, feathers, dust, orris root, and pollens either alone or in combination is necessary. In such a case it is better to employ a solution containing the four common irritants—dust, feathers, animal hair and orris root—as one or more of them will be specific for the case while the others will have a non-specific effect. By using concentrated solutions and preventing any general reaction by the simultaneous injection of three minims of adrenaline hydrochloride (1 in 1,000 solution) it is possible to desensitize the patient very successfully and rapidly. In pollen cases the specific pollen must also be added. The course of injections may be protracted over a period of many weeks, or in urgent cases completed in a few days by giving several injections a day with the patient in a nursing home under observation.

Non-specific desensitization

Non-specific treatment is based upon the idea that by using up the reactivity of the patient with one protein, reactivity to the specific protein will be counteracted. Peptone is commonly used, preferably Witte's 'peptone special 30'. This may be given subcutaneously or intramuscularly in 7·5 per cent solution, commencing with a dose of 0·1 c.c. and increasing by 0·1 c.c. twice a week up to a dose of two cubic centimetres. Severe reactions sometimes follow the use of peptone intravenously. Tuberculin, milk, 'proteose', liver extract, and vaccines have also been recommended, but the percentage of good results from non-specific treatment varies very little whichever form is used. These reagents should have very little place in the future treatment of asthma in specific cases now that potent extracts can be employed as the result of reliable skin tests, but in cases that cannot be skin-tested and the cause determined they must still find a place in treatment. Even then a mixture of the common inhalant allergens is likely to prove of more benefit than a non-specific agent.

Focal infections

Non-specific predisposing factors require appropriate treatment. Focal infections should be cleared up as soon as possible to improve the general health of the patient, although there is not any definite proof that asthma occurs from a sensitization to bacterial proteins. The only methods known at the moment by which they produce their effects are by the local production of histamine in the lungs of a sensitive patient, or by the local or general lowering of the resistance of the body to some specific allergen by the infection. In either case the removal of the specific allergen is much more likely to lead to success in treatment than is any vaccine therapy.

Tuberculosis

Tuberculosis is often suspected as a cause of asthma, but only one asthmatic patient in a hundred gives any evidence of active tuberculosis and only one patient in two hundred with active tuberculosis suffers from true asthma. When asthma does develop in a tuberculous subject the sensitizing agent is generally of an inhalant nature and the asthma is relieved by its removal or a course of specific desensitizing injections. In the rare cases in which the sensitizing agent may be bacterial in nature, it is more often a secondary invader than the tubercle bacillus. Hence tuberculin therapy is devoid of any specific reaction in asthmatics, even although they give positive tuberculin tests. Its effect is purely non-specific.

Nasal abnormalities

Asthmatic attacks are quite commonly regarded as the result of nasal abnormalities, and a series of operations may be undertaken without producing any permanent relief. Most recent observers regard nasal abnormalities as merely coincidental or directly secondary to nasal allergic manifestations. The oedema resulting from numerous repeated reactions, especially if the irritant is air-borne, finally produces hyperplasia of the lining mucosa of the turbinals and sinuses by interfering with the blood-supply and drainage. The ostia close, and so the sinuses may become fertile fields for bacterial invasion and growth. Once infected, a damaged organ results and is more likely to react to the specific allergen; in other words a sensitive area is produced. If the irritation is continued, chronic oedema and polypoid degeneration may occur, and the enlarged tissues or bony deformities then press on a certain area of the nose and produce reflex bronchospasm which may then initiate attacks in the absence of a specific allergen. From these facts it follows that the treatment of a case of asthma with local nasal lesions should be conservative, non-surgical, and along allergic lines until as good results as possible are obtained. After the subsidence of the oedema, if the nasal lesion still interferes with adequate relief, it may be treated surgically. The treatment should aim at freeing the nose from any source of infection, ensuring proper drainage and a free air-way, as well as searching for any sensitive areas and removing tissue that may be responsible for reflex pressure symptoms.

Drugs

Amongst the common medicines employed in the treatment of asthmatics iodides, atropine, belladonna, and stramonium still find their place. A frequent prescription is:

Potassium iodide – – – –	4 grains
Tincture of stramonium – – –	15 minims
Ethereal tincture of lobelia – – –	15 minims
Syrup of virginian prune – – –	30 minims
Water – – – – to	4 fl. drachms

Give one tablespoonful each four hours until the wheeze has gone.

Other antispasmodics include benzyl benzoate (dose 10 to 30 minims), liquid extract of grindelia (dose 10 to 20 minims), and tincture of euphorbia (dose 10 to 30 minims). In a certain number of cases aspirin causes asthma, but in patients without this idiosyncrasy it is a very valuable drug, and 10 to 15 grains will frequently abort an attack or lessen its severity. Hydrochloric acid is indicated in the presence of a hypochlorhydria and may be given in doses of ½ to 2 drachms of dilute hydrochloric acid B.P. in a cup of orange or lemon squash three times a day before or with meals. The addition of glucose helps from an energizing point of view, especially if many injections of adrenaline have used up the liver glycogen. Calcium is not of any value. Patients who suffer from nervousness or loss of sleep obtain great relief from phenobarbitone (luminal) or bromides, and those worried by an irritating nocturnal cough are greatly relieved by a dose of a strong linctus at bedtime, such as:

Pseudo-ephedrine – – – –	1 grain
Tincture of stramonium – – –	15 minims
Syrup of codeine phosphate B.P.C. Syrup of virginian prune – of each equal parts to –	2 fl. drachms

Give two teaspoonfuls at bedtime and repeat once during the night if necessary.

Surgery

Besides the removal of septic foci and nasal growths and deviations, bronchoscopy is the only surgical treatment of asthma deserving mention. It has as its aims the removal of excessive tenacious secretion and the application of drugs directly to the bronchial mucous membrane. Various operations on the nerve-supply of the lungs have been described, but they should only be performed as a last resort.

Physical therapy

Physio-therapeutic methods employed include electro-therapy, actino-therapy and X-ray therapy, which may produce some non-specific effects, but cannot be relied upon. Since the observation was made that most allergic conditions subside during feverish states, recent observers have employed various forms of pyrogenic therapy. At the moment it may be stated that the results of spontaneous fevers are far more efficacious in relieving asthma than any artificially induced fever whether brought about by a fixation abscess, non-specific therapy, hot baths, or by the use of the high-frequency current.

Remedial exercises

Remedial exercises are necessary in all cases of asthma in which the attacks follow each other so rapidly that the over-expanded lungs do not have an opportunity to return to their normal size and the thorax becomes barrel-shaped. They should be expiratory rather than inspiratory.

Climatic conditions

The asthmatic should be shielded from extremes of temperature, draughts, cold winds and fog. The best climate is that which (*a*) allows the most outdoor life in order to avoid the specific factors associated with the home, (*b*) has coolness, mildness, relative dryness and absence of marked variations in humidity, and freedom from marked changes of temperature from midday to midnight, (*c*) tends to produce the necessary biochemical changes in the blood of the sufferer (such as altitudes of 3,000 feet and over), and (*d*) has no association with habit.

(2)—Treatment of Attacks

Symptomatic treatment

For the immediate treatment of the acute attack, inject subcutaneously in a child 2 minims, or in an adult 5 minims, of 1 in 1,000 solution of adrenaline hydrochloride. No additional benefit is derived from the more expensive proprietary preparations which contain adrenaline mixed with other constituents; frequently they cause intense palpitation which is more distressing than the asthma as they are generally injected in doses of 1 cubic centimetre, and after they have been used for any length of time the asthma appears to be unrelieved by the usual adrenaline solution unless given in very large doses.

Adrenaline

Adrenaline rapidly relieves bronchospasm, but unfortunately its effect is of correspondingly short duration. Hence, in severe cases it is always the best procedure to leave the needle in position after giving the first dose because smaller additional amounts are sure to be required to prevent the reappearance of the spasm. A 1 c.c. Record syringe can be left filled with the adrenaline hydrochloride solution, and a relative be instructed to attach the syringe to the needle and give 2 minims of the solution at the end of one, two, four and eight hours; after this interval the attack will as a rule be over, and the patient have remained free from any recurrence in the meanwhile. In 'status asthmaticus' one or more minims of the adrenaline solution will have to be repeated more frequently—even as often as each minute until relief of the spasm is obtained, and then each quarter of an hour for the first hour, each half-hour for two hours, each hour for three hours, and each two to four hours until bedtime. In more severe cases large amounts (but small individual doses) of adrenaline are necessary, and relief from the drug appears slower and less adequate. In these cases an additional solution is necessary, made up as follows:

Morphine sulphate – – – – –	¼ grain
Atropine sulphate – – – – –	$\frac{1}{100}$ grain
Adrenaline hydrochloride solution (1 in 1,000) to	10 minims

One minim of this special solution is injected every fifth minute instead of the adrenaline alone, and the process is continued until the spasm is relieved or until the 10 minims of the solution have been injected. It is unwise to give more than ¼ grain of morphine, even by this slow method; for, should the cough reflex be abolished and the spasm subside, large amounts of mucus will be poured out from the obstructed glands, and unless this is expectorated the patient will be drowned in his own sputum. The maximum benefit from adrenaline is obtained when it is given at the earliest possible moment, in small doses, and repeated at gradually increasing intervals until the patient has been free for twenty-four hours.

Treatment after cessation of the spasm

As soon as the patient begins to experience any relief the body temperature should be brought back to normal by additional blankets and hot-water bottles, and a tablet of ephedrine hydrochloride given. For an adult ½ to ¾ grain may be ordered and repeated each six hours if necessary, while for a child the dose is ⅛ grain under one year, ¼ grain over one year, and ½ grain over seven years. Unfortunately, ephedrine causes unpleasant symptoms in a large proportion of cases, and many pharmaceutical efforts have been made to overcome these side effects. Pseudo-ephedrine, or the synthetic ephedrines, such as ephetonin, overcome these undesirable reactions in some patients. Other ways of attaining the same end are to combine with the ephedrine such drugs as amytal, i.e. isoamylethylbarbituric acid (dose ¾ to 1½ grain), or phenazone as in the ephazone tablets.

Ephedrine

If the patient is exhausted stimulants are indicated, and strong coffee in the morning, or towards evening strong hot alcohol, is advisable. Fluids are essential, and if the patient cannot take much fluid or glucose-water by mouth, a glucose-saline enema (3 ounces of glucose in 1 pint of normal saline) will serve a triple purpose; not only does it suffice temporarily for food and fluid, but also it may afford relief from flatulent distension of the abdomen, or constipation.

Use of sprays

The use of adrenaline, ephedrine, cocaine or aromatic oils in sprays, or stramonium in the form of inhalations, powders or cigarettes should be deprecated, as the relief afforded is only temporary and they have an extremely irritating effect on the bronchial mucous membrane; this, in turn, increases the liability to further attacks. Whether vaporized by hand, mechanical or electrical means they tend to change the asthmatic with acute attacks and perfectly free intervals into a constantly wheezing individual, although admittedly the spasms become less severe.

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ASTIGMATISM

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1.–DEFINITION

111.] Astigmatism can be defined as a condition of refraction in which light cannot be brought to point focus upon the retina. It can be divided into two groups—regular astigmatism and irregular astigmatism.

Regular astigmatism

In regular astigmatism the two most opposed meridians are at right angles to each other. Each meridian is a perfect curve but the radii of the curves differ. Regular astigmatism is not usually due to disease or trauma, although it may result from the pressure of tumours upon the globe, or from operations.

Irregular astigmatism

In irregular astigmatism the curves are not regular but may be most irregular and the two most opposed meridians may not be at right angles to each other. Irregular astigmatism is always pathological, being either the result of scars or wounds of the cornea, or of weaknesses due to debilitating conditions.

2.–CLINICAL PICTURE

In the practice of refraction the astigmatism chiefly dealt with is of the regular type. It can be remedied by the use of appropriate glasses. Not only can the vision be improved but the associated discomfort and eye-strain can be relieved.

Regular astigmatism can be classified as follows:

Varieties of astigmatism

(*a*) Hypermetropic astigmatism in which one meridian is normal and the other hypermetropic. (*b*) Myopic astigmatism in which one meridian is myopic and the other normal. (*c*) Compound hypermetropic astigmatism in which both meridians are hypermetropic but one more than the other. (*d*) Compound myopic astigmatism in which both meridians are myopic but one more than the other. (*e*) Mixed astigmatism in which one meridian is myopic and the other hypermetropic.

In regular astigmatism as previously mentioned, the two most opposed meridians are always at right angles to each other, but their axes, though at right angles to each other, are not necessarily directed vertically and horizontally. This state of affairs is sometimes spoken of as oblique astigmatism. All degrees of regular astigmatism have some effect upon visual acuity. In the low degrees this may be very slight indeed, but in the high degrees it will be considerable. If the condition is one of compound astigmatism the astigmatic element may be swamped by the spherical element—e.g. in high myopic astigmatism. In cases in which this is not so, it is rather characteristic that on reading the test-type some lines will be read easily, after which another line or two will be read imperfectly, letters being missed here and there. This should suggest an astigmatic error.

Symptoms

It may be concluded then that any considerable astigmatic error will impair visual acuity, but when symptoms of strain or discomfort are considered one enters upon an uncharted sea. In general, it can be said that with the larger errors the visual reduction is greater, and the symptoms less, whereas with the smaller errors the reverse is the case. The disturbing effects on individuals of astigmatic errors vary greatly, and it is impossible to make hard and fast rules. Headaches and feeling of strain about the eyes may be the result of many differing factors, physical and psychological. This is not surprising considering that the eyes are the chief means of contact with the outside world.

Personality of ophthalmologist

Authoritative ordering of glasses may have beneficial results by the effect of suggestion rather than by the actual correction of the optical error. The ophthalmologist should impress his personality on the patient, for this has distinct therapeutic value and may explain the anomaly of the equal successes of two opposing schools—those who believe in the meticulous correction of minute refractive errors, and those who do not; however, the middle course is usually the right one. With regard to the improvement of the actual visual acuity firmer ground is approached.

3.–ESTIMATION OF ASTIGMATIC ERROR

The estimation of the astigmatic error can be made by either of two methods, (1) retinoscopy or (2) subjective testing. The best results are undoubtedly obtained by a combination of the two.

Retinoscopy

Retinoscopy performed under mydriasis should theoretically give complete information about the state of refraction of the eye; the method, however, has practical difficulties. In some cases it is very hard to make an exact reading, and it is never easy to estimate by retinoscopy the exact axis of the cylinder. This is best determined by subjective testing, although in young children in whom of necessity retinoscopy must be the final court of appeal, more accurate results can be obtained by neutralizing the lowest meridian by a sphere and then adding and manipulating cylinders until the neutralization point of the highest meridian is reached. In this way the axis of the cylinder can be judged with fair accuracy.

In children

As previously stated, the most exact results can be obtained by first performing retinoscopy, and, with the findings from this, checking the details of the axis of the cylinder and the exact strength of sphere by subjective means. The experienced refractionist can get very accurate information by retinoscopy without a mydriatic, but when a mydriatic has been used, a post-mydriatic test a day or two later is often advisable.

Subjective testing

Subjective testing, if done according to plan, can give very accurate results. A good scheme is to find the highest plus sphere with the highest minus cylinder (the latter at the appropriate axis) which gives the best vision; or, if the total refraction is on the myopic side, the lowest minus sphere with the highest plus cylinder (also at the appropriate axis). It is important to peg the accommodation by obtaining the highest plus sphere or lowest minus sphere which will be accepted. The same plan is adopted with the astigmatic fan. When the highest plus sphere with which the patient can just make out the fan has been found, then the minus cylinder should be placed with its axis at right angles to the clearest line on the fan, and the strength of the cylinder increased until all the lines of the fan appear equally clear.

The crossed cylinder

The crossed cylinder (Fig. 38) can be usefully employed to determine the axis of the astigmatism. It is a glass in which the two most opposed meridians are minus and plus. The usual form employed is a combination of $-0{\cdot}25$ D sphere, with a $+0{\cdot}5$ D cylinder.

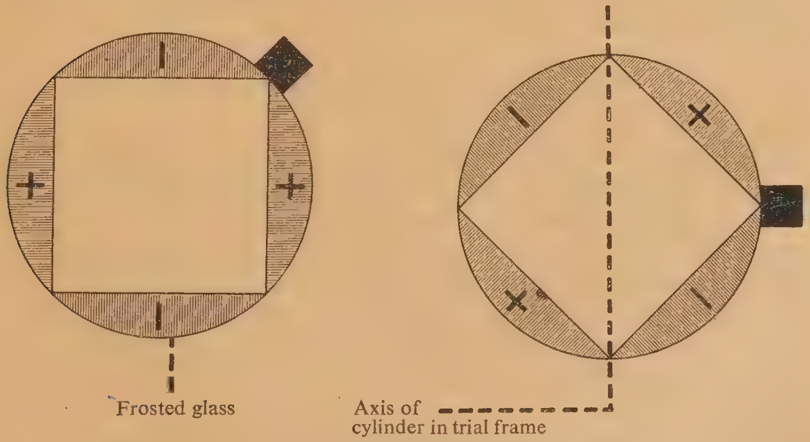

FIG. 38.—The crossed cylinder

The calculated correction of sphere and cylinder having been put in the trial frames, and the patient told to look at the test-type, the crossed cylinder is then placed in front in such a way that its two axes lie equally either side of the axis of the cylinder (Fig. 38); then the crossed cylinder is rotated so that its opposite face is against the trial frames, and the patient is asked whether this makes the test-type clearer or less clear. Should it make no difference, the axis is correct; if, however, there is a difference, and the test-objects appear clearer with one face of the crossed cylinder than the other, the cylinder in the trial frames must be moved until a position is found in which the test-objects appear equally clear when either face of the crossed cylinder is applied.

Apparatus

There are many different kinds of apparatus to assist subjective testing, but very accurate work can be done with lenses, cylinders and test-types, and no complicated apparatus is essential. There are many varieties of astigmatic fans, but all are based on the same principle (see Fig. 39). Mention should be made of the ophthalmometer. This instrument measures the curvature of the anterior surface of the cornea. It neglects the lenticular astigmatism, and does not estimate the spherical element; as most astigmatism is corneal in origin, it measures the most important factor. The spherical element can be found subjectively, and by one accustomed to working with the instrument the lenticular factor (which is approximately +0·5 axis 180°) can be inferred. The instrument is costly but has its devotees.

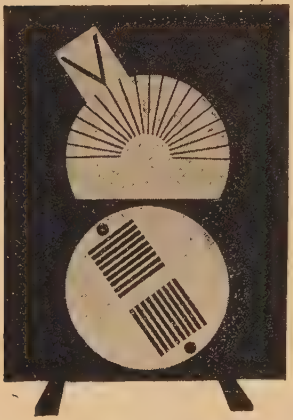

FIG. 39.—Astigmatic fan

4.–TREATMENT

Regular astigmatism

The astigmatic error having been estimated, the full correction should be ordered if it is decided to advise its aid at all. The full correction is usually borne quite readily. A point to be remembered is that when eyes are used for near range as in reading, there may be some small alteration in the axis of the astigmatism owing to slight cyclophoric torsion which often occurs when the eyes are converged. When high cylinders are ordered, it is well to insist on rigid frames set firmly on the face, as very slight deviation from the true position will cause discomfort and affect visual acuity.

Irregular astigmatism

Irregular astigmatism cannot be accurately corrected by glasses as it obviously conforms to no optical system. In the smaller degrees, however, much help can be given by cylinders, though their selection can be made only by trial and error. The condition can be adequately met by contact glasses when the corneal surface alone is involved, and when there is no opacity. There is some difficulty at first in the insertion of the contact glass, and it may be some time before the glass can be worn for long periods. In suitable cases immense improvement in vision is obtained.

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ATAXY

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Reference may also be made to the following titles:

BRAIN: REGIONAL DIAGNOSIS	HEMIPLEGIA
CEREBELLAR DISEASES	NEUROSYPHILIS

1.–DEFINITION

112.] Ataxy may be defined as an irregularity or disorderliness of movement. The word 'inco-ordination' is often used as synonymous with ataxy. As thus broadly defined ataxy must be said to include certain disorders of movement to which the term is not commonly applied: e.g. the disorder of movement that may be produced by the presence of Parkinsonian tremor in a moving limb. In practice the term has come to be confined to two main forms of motor disorder: the first resulting from disease of the cerebellum or of its connexions and known as cerebellar ataxy; the second resulting from loss of postural sensibility in the moving parts and known as sensory ataxy.

2.–FACTORS UNDERLYING THE CO-ORDINATION OF MOVEMENT

First grade of co-ordination

An account of the nature and different forms of ataxy calls for a brief statement of the factors concerned in the normal co-ordination of movement. In a simple voluntary movement, such as closing the hand, the muscles concerned fall naturally into three groups: (i) the prime movers, in this case the flexors of the fingers, which produce the desired position; (ii) the antagonists, in this case the extensors of the fingers which relax and lengthen; and (iii) the synergists, in this case the extensors of the wrist which contract to keep the hand in the position of maximum efficiency and to prevent the wrist from going into flexion under the influence of the contracting finger flexors.

The reciprocal relationship between these three groups of muscles must be perfectly adjusted: lengthening and shortening, increasing and diminishing tension must correspond in degree if co-ordination is to be achieved. This reciprocal innervation is the first grade of co-ordination, and it is extremely doubtful if it is ever overset in any of the forms of ataxy seen clinically. It is a function of spinal centres and is deeply organized in the nervous system.

Higher grades of co-ordination

Higher grades of co-ordination assure that complex movement combinations and sequences shall be harmoniously related, and this is achieved by the cerebral cortical centres, which act upon the spinal motor centres directly through the pyramidal system, and indirectly through the cerebellum and basal ganglia and their projection systems.

Cerebellar ataxy

In some as yet undiscovered way the integrity of the cerebellum is essential to the performance of co-ordinated voluntary movements. It is probable that the cerebellum is concerned in the adjustment between the movement and postural components of our motor activities, and that when it fails to act (by reason of disease or injury) the postural component is lacking and cerebellar ataxy results. For example, when writing on a blackboard the muscles of the forearm and hand carry out the rapid, finely adjusted movements of writing, while the proximal arm and the trunk and leg muscles maintain the individual in a position in which this writing is possible. Cerebellar ataxy may be the expression of the falling out of this postural adaptation and fixation.

Sensory ataxy

The second variety of ataxy is due to an interruption of the sensory pathway from the muscles, and to a resulting impairment or loss of postural sensibility (sense of position, appreciation of movement).

The nervous system is built upon the pillar of the sensory neurone, and the information which this conveys from the environment, from the body surface and from the moving parts may be said to govern the activities of the organism. In particular, it is essential that accurate information should reach consciousness as to the position of the body and of its component parts in relation to space and to each other, and also as to the degree of movement occurring at any given time.

If this information is lacking, then movement becomes ataxic. The sensory pathway from the muscles, tendons and joints (proprioceptive system) may be interrupted at any part of its course from the peripheral nerve, through the spinal cord and brain-stem to the thalamus and cerebral cortex. The disorder of movement which ensues is the same in kind no matter where the interruption occurs.

Before proceeding to describe these two forms of ataxy, it may be observed that in cerebellar ataxy there is no defect of any form of sensation, whereas in the so-called sensory ataxy, sensory loss is the direct cause of the disorder of movement.

3.—CEREBELLAR ATAXY

(1)—Clinical Picture

Nomenclature The detailed analysis and description of this disorder of movement has been rendered unnecessarily difficult and complicated owing to the redundant nomenclature which is in current use to describe the various aspects of it. Unhappily, too, certain of these terms are used in different senses by different writers; while in other instances there are two or more terms all in use to describe a single symptom. Therefore, while we must perforce employ the terminology in current use, some of its terrors may be eliminated by considering the way in which it has come to be devised.

It will be readily understood that if we are studying a general disorderliness of movement, such as cerebellar ataxy, the actual form which it will take at any moment in our examination will depend upon the muscles which are in use, and also upon the particular movement attempted: that is to say, the ataxic phenomena seen will depend upon the test employed. Thus, if we are testing the ocular muscles, we ask the patient to look to the side. At once we see a tremor of the eyes to which the name of nystagmus has been given. If we now test the arm muscles by asking the patient to put his finger to his nose, we again see a tremor to which (from the circumstances of its production) the name of intention tremor has been applied. If we now ask the patient to put out his hand to pick something up, the arms jerk forwards in a series of starts in the last of which the object may be overshot and perhaps knocked over. To this expression of tremor, the term dysmetria has been applied. Here we already have three separate terms in use to describe what is in its nature a single defect of muscular movement, namely, intention tremor.

Nystagmus

Intention tremor

Dysmetria

In more complex movements the disorder assumes more complex forms. Thus, if we ask the patient to pronate and supinate his hand alternately, each movement is jerky, each tends to overshoot its proper limits, and as a result each component tends to take longer than normal. The final result is a slowness, clumsiness and irregularity of this continued movement to which Babinski has given the name adiadochokinesis. It is often supposed that this is an elementary component of cerebellar ataxy that might in fact exist by itself, yet it is clearly but another expression of the disorder that has already been considered. If there were no intention tremor there could be no adiadochokinesis.

Adiadochokinesis

In short, these terms are purely descriptive. They have no value in an analysis of cerebellar ataxy, and they tell us nothing of its cause or nature. We may now proceed to enumerate the different manifestations of cerebellar ataxy as revealed in a systematic examination of the patient, inserting these terms in their appropriate place, but trying as far as possible to make the description independent of them.

Ocular movement

Ocular movements: In unilateral lesions of the cerebellum (tumour, abscess) there is a slow coarse nystagmus on deviation towards the side of the lesion, and a fine and rapid nystagmus when deviating the eyes to the side away from the lesion. In some cases, there is a great difficulty in deviating to the side of the lesion and a full range of movement may be impossible. In bilateral lesions a nystagmus of equal phase may be present on deviation to either side. In certain atrophies of the cerebellum (cortical degeneration, olivo-ponto-cerebellar atrophy) there is usually no nystagmus.

After severe injuries to the cerebellum there may be a transient appearance of 'skew deviation' of the eyes. The eye on the side of the lesion is deviated downwards, the opposite eye upwards.

Articulation

Articulation: The terms 'scanning' or 'staccato' speech are applied to the disorder characteristic of cerebellar ataxy. The syllables of a word, instead of being run together normally, are pronounced slowly, deliberately, and separately as though each were a word. In the more severe degrees, articulation may be almost unintelligible.

Arm movements

The Arms: To study the disorders of arm movement it is best to prop the patient up so that head and trunk are supported. We will assume for simplicity of description that the lesion is unilateral. As the arms rest upon the patient's lap they are free from all tremor. Volitional activity is the essential condition in the production of all disturbances of function in cerebellar ataxy. The patient is asked to extend his arms horizontally. The affected arm is not brought up smoothly, but jerkily and with some deviations from the straight course, though in the milder degrees of disorder this may not be noticeable. The arm may remain still when extended, but usually tends to fall away and to be brought back to the original level by a jerk. This repeated fall and restoration may continue, a slow falling away and a quick voluntary jerk back to the horizontal, and the phenomenon is clearly the same as that known as nystagmus when it is seen in ocular muscles. This is the so-called action or intention tremor.

Intention tremor

Intention tremor is, however, rendered more obvious by movement. In the finger-nose test the patient is asked to extend the arm and then to put his index finger on his nose. The arm proceeds jerkily, each jerk increasing in range and rapidity as the nose is approached—that is, as the demands upon co-ordination increase—and finally the finger beats a tattoo on the nose. This is referred to as the crescendo character of intention tremor. If the patient's eyes be closed, the tremor is not increased and the nose is accurately reached: that is, there is no error of projection such as is a prominent element in sensory ataxy.

Rebound

The patient is now asked to make his extended arms rigid, and the observer gives each of them a smart tap on the dorsum of the hand. The normal arm is depressed, but quickly brought back to rest at the original level. The ataxic arm drops through a wider range when tapped, and is brought back to normal by a series of pendular swings. This is a clinically striking and valuable sign in cases of unilateral cerebellar lesion (e.g. abscess) and may be present when many other signs of cerebellar ataxy are absent. A similar excessive rebound may be seen if the patient is asked to flex the arm against resistance—the resistance being then suddenly released. The affected arm then bounces up and may strike the patient's face, whereas the normal arm is very quickly 'braked' and brought to rest after a much shorter excursion.

The capacity to perform alternating movements may then be tested. The patient keeps the elbows at his side, flexes the forearms to a right angle so that they come to extend horizontally forwards. He is then asked to pronate and supinate the hand alternately and as quickly as he can. The affected limb performs these movements less rapidly than the normal, each component tends to be excessive in range, the successive movements are not equal in range and they vary in direction and smoothness (they show intention tremor). The fixation of the limb as a whole is defective and adventitious movements come in and produce still further disorder of rhythm and timing. This is the phenomenon to which Babinski gave the name adiadochokinesis.

The phenomenon known as dysmetria is, as we have seen, a necessary consequence of an intention tremor and need not be further considered.

Leg movements

The Lower Limbs. When the patient lies supine on the bed and carries out movements with the legs, these show the same disorders as have been noted in the arms. They are usually revealed by heel-to-knee and other test movements. The disorder of gait will be considered separately.

Muscle tone

Reflexes

Muscle Tone and Tendon-Reflexes. In the case of acute and recent lesions of the cerebellum, it may be found that the muscles are abnormally soft and extensible on passive movement, so that the limbs may be placed in abnormal positions: such, for example, as hyperextension at wrist or knee. Also, in these circumstances, the knee-jerk takes on a characteristic pendular quality, the leg swinging slackly before it comes to rest. There is, however, no other change in the tendon-jerks in an uncomplicated cerebellar lesion.

Stance and gait

Stance and Gait. It will be obvious that standing and walking are complex movements in the sense that they employ wide regions of musculature in a series of alternating movements. Therefore we must expect that the disorders already considered will appear much more disabling and striking than in the movements of a single limb, or muscle group. This is indeed the case, and a number of special terms have been coined to describe the various defects observed.

In general it may be said that the patient tends to sway as he stands, in the case of unilateral lesions to the affected side. To counteract this he stands on a wide base and is constantly correcting with his tremulous muscles the involuntary swaying movements. This voluntary effort to overcome the defective action of the musculature itself tends to keep up the unsteadiness. In walking the feet are kept widely apart, and are stamped jerkily down. The action of the limb and trunk muscles by which the centre of gravity is kept between the subject's feet is also defective and he may fall to one or other side, backwards or forwards unless supported. In the slighter degrees of ataxy of gait, the defect is best elicited when the patient turns round. Titubation, asynergia, decomposition of movement, discontinuity of movement and ataxy are various terms used in different senses by different writers in the attempt to clarify this complex disorder of movement, but it is doubtful if their employment really assists description or comprehension.

These disorders of stance and gait do not, as we have seen, depend on any defect of postural sensibility and therefore they are not increased when the patient's eyes are closed: that is to say, Rombergism is not present in cerebellar ataxy.

Clinical types

Clinical Variations in Cerebellar Ataxy. The disorders already described represent the complete picture of cerebellar ataxy, but it will be understood that not all these are present in every case. For example, in cerebellar abscess the patient may be too ill for many of these tests to be carried out, or for any but the simplest movements to be possible. In these circumstances, valuable localizing indications are the falling-away of the extended hand on the side of the lesion, the excessive rebound when the extended arms are tapped, and the presence of a difficulty in conjugate deviation of the eyes to the side of the lesion or of a coarse slow nystagmus. Intention tremor in the hand and arm may also be noted.

Again in certain slowly progressive lesions, such as glioma of the cerebellum, a very blurred and incomplete picture of cerebellar ataxy may be present. The disorders of gait may appear only when the patient walks on a slope or upon broken ground.

In the primary cerebellar atrophies, there may be gross disorder of all movements but complete absence of nystagmus.

(2)—Localizing Value of Cerebellar Ataxy

The ataxy described may accompany lesions within the cerebellum in any of its lobes, and may also be produced by compression of the cerebellum from without, as by an auditory-nerve tumour in the lateral recess of the posterior fossa. Degenerative lesions affecting the spino-cerebellar tracts may also give rise to ataxy, as in Friedreich's ataxy and in spino-cerebellar ataxy. It will be remembered that in such gross lesions as abscess or intra- or extra-cerebellar tumour, there may also be involvement of the vestibular nerve and apparatus. Nystagmus may owe its presence to this factor, and we have seen that it is absent in cerebellar atrophy.

Acute lesions or functional disturbances of the labyrinth may also give rise to ataxy of movement and vertigo as part of their clinical picture. These will be dealt with under their appropriate heading.

4.–SENSORY ATAXY

(1)—Clinical Picture

This variety of ataxy is familiar as a prominent symptom of tabes dorsalis. Some of its features may be foretold when we consider that a loss of postural sensibility (sense of position, appreciation of movement) underlies this form of disorder. Thus, we shall expect that vision will be in a measure able to supply the information lacking from the muscles themselves and thus to minimize the ataxy. Conversely the deprivation of vision by closing the patient's eyes may be expected to aggravate the ataxy. This fact is the basis of Romberg's sign, and it may be appropriate to note here that Rombergism is to be interpreted not as a sign of tabes dorsalis pure and simple, but as a sign of loss of postural sensibility in the lower limbs caused by a lesion of the sensory pathway from the muscles at any part of its course, whether by the tabetic or by any other process which interrupts this path.

Rombergism

Eye movements

Ocular Movements and Articulation. Clinically, there are no known disorders of these movements that we can attribute to sensory loss in the muscles involved. The extrinsic ocular muscles, in fact, are apparently immune from many disorders that may affect the rest of the skeletal musculature: as for example, the disorders of chorea and the tremor of paralysis agitans. It has been suggested that the occasional diplopia of tabes dorsalis may be due to ataxy of ocular muscles, but it is extremely doubtful if this is the case.

Arm movements

Upper Limbs. The extended hands tend to fall away, the subject being unaware of this if his eyes be closed. In addition, the fingers and hand sometimes pass into slow irregular, writhing movements of which also the patient without vision is unaware. The name of pseudo-athetotic movements, from their resemblance to athetosis, has been given to these movements. The patient may be able to put his finger to his nose with fair accuracy if his eyes be opened, but without vision the arm and finger tend to wander and thus to show an error of projection which is a characteristic feature of sensory ataxy in the upper limb. Similarly, the patient may have difficulty in directing his hand into his trousers pocket unless he keeps his eye on it, and once in his pocket the loss of postural sense in the digits may make it impossible for him to pick out

Pseudo-athetosis

Astereognosis

the desired object from among several in his pocket: that is, he may have astereognosis. The fine movements of writing are especially impaired.

Leg movements

The Lower Limbs. These present disorders of the same kind as those described for the arms, disorders which are aggravated by depriving the patient of vision.

Stance and gait

Stance and Gait. In its more severe degrees and when involving all four limbs, sensory ataxy may totally disable the patient, who cannot stand, step, or make any co-ordinated movements of arms or legs. An ataxy of this degree, if it supervene acutely, may at first sight be mistaken for a true motor paralysis, but of course a routine examination will reveal that power is not diminished in the muscles. In mild degree, the gait of the ataxic tabetic is wide-based, stamping and disorderly in the sense that movements of excessive range and erroneous direction are made. To gain some measure of control, the patient may use one or two sticks, and walks with his eyes fixed upon his legs so as to direct them by vision. In the slightest degrees, recognizable ataxy may appear only when the subject's eyes are closed (Rombergism).

Passive movements

In the tabetic this ataxy is commonly accompanied by muscular hypotonia and relaxation of the ligaments, so that passive movements of extreme range may be made with the legs.

2)—Localizing Value of Sensory Ataxy

The pathway by which the impulses underlying postural sensibility travel is along the mixed peripheral nerve into the root-entry zone of the spinal cord, thence along the posterior column of the side of entry, through the brain-stem by the median fillet, to the thalamus and thence to the sensory region of the cerebral cortex. Interruption of this path at any level may give rise to ataxy in the limb or limbs deprived of postural sensibility. Thus, in multiple peripheral neuritis, the legs may show sensory ataxy with a corresponding disorder of gait and movement. Lesions of the posterior columns of the cord, as in tabes dorsalis, Friedreich's ataxy, subacute combined degeneration of the cord, and disseminated sclerosis, may all lead to sensory ataxy.

Similarly, local lesions involving the median fillet or the lateral nucleus of the thalamus may have similar consequences. Some ataxy of movement may follow a lesion of the sensory cerebral cortex.

5.–DIFFERENTIAL DIAGNOSIS OF CEREBELLAR AND SENSORY ATAXY

The features of these two forms of ataxy, and the other abnormalities of nervous function which may accompany each of them, will both serve to make differentiation possible.

Postural sensory loss

There is no postural sensory loss in an uncomplicated cerebellar ataxy, and deprivation of vision does not intensify the disorder. In movements of the hand and arm made with closed eyes there is no error of projection in cerebellar, but marked error in sensory ataxy.

Nystagmus Nystagmus is a common accompaniment of cerebellar ataxy, but not of sensory ataxy.

Tendon-jerks Among the signs of diagnostic value are the loss of tendon-jerks and the cutaneous sensory loss that commonly accompany a sensory ataxy.

Mixed types In some cases of disseminated sclerosis the limbs may present a mixed cerebellar and sensory type of ataxy, and in Friedreich's ataxy the disorder of movement in the legs may be due to postural sensory defect, that in the upper limbs being cerebellar in type.

6.–OTHER VARIETIES OF ATAXY

Following hemiplegia Considerable clumsiness of movement is commonly seen in the limbs after partial recovery from hemiplegia. In the case of the hand, all fine movements may be lost or gravely impaired. Two factors share responsibility for this disorder, which in effect is a form of ataxy. The first factor is that many fine hand and finger movements are lost, only the simpler and larger movements—such as grasping—being preserved. The second factor is the hypertonus which has invaded the musculature and limits the range and reduces the speed and fineness of such movements as remain. If such a subject is asked to perform alternating pronation and supination of the hand, the resulting movements differ very little in appearance from the adiadochokinesis of cerebellar ataxy—except perhaps in that they are even slower.

As in sensory ataxy the essence of treatment is re-education by active exercises, so also in this form of 'cerebral ataxy' active movements form the most valuable element in treatment.

7.–TREATMENT

In many clinically observed examples of ataxy, the question of direct treatment of this disorder does not arise. Thus, in cerebellar abscess or tumour, or in cerebellar thrombosis, the needs of the patient's general state dominate and determine treatment. In circumstances in which ataxy is left as a residual symptom of an inactive pathological process, or in such a malady as tabes dorsalis, some measures may be required to improve a chronic disability in movement.

In the case of cerebellar ataxy such a state of affairs is most characteristically seen in the progressive cerebellar atrophies, and in them it cannot be said that any form of massage or physiotherapy has any influence whatever upon the ataxy. This is true, also, of those cases of disseminated sclerosis in which a cerebellar type of tremor and ataxy constitute the main disability. Such cases rarely show the intermissions so typical of this disease and are very resistant to any measures designed to mitigate the unsteadiness of movement.

Re-education In sensory ataxy the situation is not always so hopeless. Particularly in the acutely developing ataxy of some cases of tabes, systematically undertaken re-education exercises of the kind devised by Fraenkel may be of the greatest value and sometimes a dramatic improvement may be achieved by their means. The basis of these exercises is the performance by the patient of a progressively graded series of movements of a limb, in which the foot is placed in positions marked out on canvas strips, or (in the case of bed-exercises) on simple wooden appliances. As control of movement is gained, the exercises increase in complexity, and from bed-exercises the subject passes to ambulant exercises. It is obvious that Fraenkel's regime of exercises is not easily obtained in its complete form, but in many cases a more or less adequate substitute may be obtained by making the patient (with or without the aid of hand-rails) walk along a tiled passage in which the lines of the flooring may be used to mark the limit of each step.

In the case of an ataxic hand, the playing of solitaire or the handling of dominoes and other small objects has a re-educative function.

It is important when there is sensory ataxy of the legs, as in tabes, not to confine a patient to bed unless this be imperative, as such confinement is commonly followed by increased disability of walking.

Massage alone is of very doubtful usefulness as a corrective of ataxy, although it may improve the general condition of the musculature.

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ATHETOSIS

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Reference may also be made to the following titles:

BIRTH PALSIES	CHOREA
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1.–DEFINITION

113.] The term 'athetosis' (mobile spasm) is applied to slow, irregular, involuntary movements, usually most pronounced in the hand, which are seen in some cases of hemiplegia. They occur more often with congenital or infantile hemiplegia than with hemiplegia acquired later in life.

The term 'double athetosis' (bilateral athetosis, *athétose double*) is used in a wider sense to denote a complex syndrome independent of hemiplegia in which slow, irregular, involuntary movements affecting both sides of the body are a prominent feature.

2.—SIMPLE ATHETOSIS

(1)—Aetiology

Site of nervous lesions

Although unilateral athetosis is, as a rule, associated with hemiplegia or hemiparesis indicative of a lesion of the pyramidal motor system, several facts demonstrate that athetosis itself does not depend on a lesion of this system. In the first place, essentially similar irregular movements are met in the symptom-complex known as double athetosis (see p. 216) in which no signs of pyramidal disturbance are present. Secondly, athetosis is evidently closely related to chorea, and chorea ordinarily occurs without any indication of associated pyramidal disease.

It is still undetermined which structures in the extra-pyramidal motor mechanism are affected. The presence in many instances of sensory disturbances, indicative of damage either to the contralateral thalamus or to the sensory tracts at a lower level, suggests that athetosis is due to a lesion of the thalamus itself or of some neighbouring structure. In few of the limited number of cases examined post mortem is the lesion sufficiently circumscribed to allow precise deductions to be drawn. In some instances the chief lesion has been in the contralateral sub-thalamic region, in others in the caudate nucleus, in still others in the lenticular nucleus, but in many of these the thalamus has been damaged as well. Whatever the site of the damage it is apparent that a merely destructive lesion cannot give rise to the stimuli that are responsible for the irregular movements and the muscular spasm. The site of origin of these stimuli is still unknown. Whether they arise in consequence of the release of some nucleus from a higher control, or as a result of the perverted activity of damaged structures, has yet to be decided.

(2)—Pathology

Nature of nervous lesions

In the production of the symptoms the nature of the lesion is much less important than its site. In infantile hemiplegia there is usually extensive damage to the cerebral hemisphere and considerable shrinkage of it as a result of the contraction of glial 'scar tissue' on the side opposite to the palsy. In such cases this shrinkage is probably responsible for the damage from which athetosis results. In acquired hemiplegia with associated athetosis the lesions are practically always of a vascular nature. Tumours rarely give rise to athetosis. Occasionally inflammatory lesions are responsible and these are usually tuberculomas. Encephalitis epidemica may cause athetosis or athetoid phenomena, not in the stage of acute inflammation, but in the stage of post-encephalitic scarring or degeneration.

(3)—Clinical Picture

(*a*) *In infantile hemiplegia*

As seen in its most typical form in infantile hemiplegia, athetosis has the following characters. The affected limb is the site of considerable

Athetoid posture spasticity and is held close to the body and flexed to a right angle at the elbow. The wrist is strongly flexed but the fingers are strongly hyper-extended at their bases and fully extended or even retro-flexed at their intrinsic joints (athetoid posture). The hand and digits are in slow continuous movement. The hand is moved by rotation of the forearm in slow, irregular, writhing, pronation-supination movements with a strong tendency to hyper-pronation, and the digits, kept fully extended at their intrinsic joints, flex and extend and adduct and abduct at their basal joints. Each digit seems to move more or less independently, and the thumb often turns across the palm, so that at one moment the fingers form a tapering bunch with the thumb hidden, and at another, especially when the hand is hyper-pronated, all the digits are spread to the utmost like an open fan. The muscles of the forearm are all in strong spasm and each movement is apparently greatly retarded and limited by the spasm of muscles opposing it. The forearm of the affected side may be somewhat thicker than that of the normal side from excessive development of the muscles affected by this mobile spasm.

Lower limb Similar movements are usually present in the foot on the same side, but are less marked. Frequent movements of limited degree are seen in the toes and the great toe is affected by strong spasms of extension and tends to be held almost at right angle with the dorsum of the foot, Lateral movements of the foot resulting from internal and external rotation of the leg are also common. All these movements are increased when the patient is excited or active, and considerably reduced when he is at rest: they cease during sleep.

Onset of athetosis In infantile hemiplegia athetosis does not usually appear until several years after the onset of the hemiplegia, but the interval is variable.

(*b*) *In acquired hemiplegia*

Upper limb The features of athetosis in acquired hemiplegia are less constant. There is less spasticity and greater power of voluntary movement. This, with the less marked adduction and flexion of the affected arm, permits the voluntary determination of posture during rest. When, however, the patient makes an effort, e.g. when he begins to walk, the affected limb usually takes up a posture of flexion at the elbow and wrist; adduction is variable. In rare cases the arm remains more or less constantly in a position of extension by the side of the body, but the wrist is flexed and the whole limb is hyper-pronated. In consequence of the less severe spasticity the movements of the head and fingers are freer than in the infantile cases. Their quality is much the same as that already described and they may be of all degrees from a slight inconstant movement of the thumb alone to severe continuous writhing of the whole hand. The irregular movements may involve the upper arm and shoulder so that when the hand is outstretched there is a vertical 'dancing' movement from the shoulder. In some cases the involuntary movements of the hand are increased with voluntary movement.

Athetosis following a 'stroke'

A patient with athetosis after a 'stroke' may possess fairly good voluntary power in the affected arm, but in spite of this the limb is, as a rule, severely disabled. Several factors are responsible for this. Not only are there the involuntary movements and the automatic changes of posture that have been mentioned, but, more often than not, there are in addition sensory disturbances. The hand is often hypersensitive to painful and thermal stimuli and may be the site of spontaneous pain; the sense of position in it, too, may be severely impaired. All these combine to discourage the patient and he gives up the attempt to recover the use of his hand.

Lower limb

In the lower limb of the stricken side the movements of athetosis are similar to those that have been described in cases of infantile hemiplegia. Here too there are several disabling factors and the patient with athetosis even although he retains considerable voluntary power is generally more disabled than the ordinary hemiplegic. Whereas in the latter the affected leg remains rigid in extension and can be used as a prop in walking, in the athetotic patient the effort of walking is often accompanied by a tendency to flexion of the leg at all its joints, so that the foot is raised high from the ground, and the patient has to make an effort to extend the limb and get his foot to the ground. Progress in learning to walk again is thus retarded, and in severe cases the ability to walk without assistance is never recovered.

(4)—Treatment

Drugs

No treatment has been discovered which has more than a slight effect in reducing athetosis. Sedatives such as potassium bromide and phenobarbitone (luminal) have practically no influence. Hyoscine and gelsemium have little more. Hyoscine is, however, worth a trial and should be given orally to the adult patient in a dose not exceeding in the first instance $\frac{1}{160}$ grain of hyoscine hydrobromide, in solution, three times a day. If the patient tolerates this amount well the dose should be increased after a few days to $\frac{1}{100}$ grain three times daily. This dosage is usually required before the patient notices any diminution of the movements or spasm. If the treatment is helpful it may be continued indefinitely. More often its effect is so slight that the patient does not think it worth while to persist with it. In patients who tolerate hyoscine well, a dosage of $\frac{1}{75}$ grain three times daily may be tried. Of gelsemium the dose is at least 30 minims of tincture of gelsemium (B.P.C. 1934), three times daily. This is in excess of the Codex dose and should be attained gradually.

Physiotherapy

Massage cannot have more than a local effect and therefore is of no curative value, there being no lesion in the limb itself. Electrical treatment is equally useless and is contra-indicated by the presence of spasm.

Surgery

Operative methods have been tried. It is on record that Horsley abolished athetosis in one patient by excision of the 'left hand' area of the cerebral cortex, and in recent years local cortical excision has been practised with success in a few instances.

3.–DOUBLE OR BILATERAL ATHETOSIS (ATHÉTOSE DOUBLE)

(1)—General

Double athetosis is a symptom-complex with slow, irregular, involuntary movements and muscular rigidity, without signs of disease of the pyramidal tracts. It is thus a syndrome which occurs in extra-pyramidal disease.

(2)—Aetiology and Pathology

In the great majority of cases double athetosis is present from infancy. In many, but by no means all, there is severe mental deficiency, evidently the result of a congenital abnormality of the brain. In these congenital cases the syndrome is fully established nine months or a year after birth and thereafter remains stationary.

Occasionally the disorder is acquired, beginning in childhood or early youth. The writer has seen three cases in which the symptoms were first noticed about the age of twelve. Such patients usually show a slow, progressive aggravation of their condition. The rigidity alone may increase and the movements then show some diminution. In a few cases, the syndrome after a period of aggravation becomes stationary. It is rare to see these patients in middle life; presumably they die at an early age. When the disorder is acquired the nature of the underlying disease is unknown. It is possible that it belongs to the group of early degenerative nervous diseases (cf. Friedreich's ataxy); but inflammatory disease cannot be excluded.

Post mortem findings

The few cases of athetosis that have come to autopsy have shown extensive degeneration of the basal ganglia. The degeneration is less intense than in Wilson's disease (progressive lenticular degeneration). Macroscopically the corpus striatum is much reduced in size and under the microscope it shows a condition which has been called status marmoratus or *état marbré* (Vogt); over small areas of the section the nerve-cells are lacking and in their place is a peculiar felt-work of very fine myelinated fibres.

(3)—Clinical Picture

The movements are of very variable degree from case to case, and in the same individual the two sides of the body are usually affected unequally.

The face

The face is practically always involved and is the site of irregular spasm and twitchings so that the patient is constantly making grimaces. When he talks or laughs there is great overaction of his facial musculature. The tongue is also affected by involuntary movements and this causes irregularity of articulation and much 'mouthing' of the words, but if muscular rigidity is pronounced speech becomes subdued or mumbling.

Head

The head is flexed or extended or rotated spasmodically in association with movements of other parts.

Upper limbs

In the upper limbs the movements are as a rule larger than those of simple athetosis, and usually affect a whole limb. A common and typical movement is one of abduction and extension of the arm with hyper-pronation of the forearm, flexion of the wrist and full extension and abduction of the fingers. Such movements are much slower than those of chorea. They subside and recur continuously in modified and often bizarre forms when the patient is active. They may almost cease during rest, but seldom cease entirely except during sleep. They are increased by voluntary movements, by emotion and by external stimuli. The action of walking is almost always accompanied by such involuntary and irregular movements in the upper limbs, and in one case under the writer's observation a slow movement which carried the hand up over the head often accompanied smiling. In the lower limbs the movements are usually less pronounced. A common form consists of flexion at the hip and knee and extension at the ankle with strong dorsiflexion of the great toe and spreading of the other toes. Often the movements in the lower limbs are limited to the toes and feet.

Lower limbs

Muscular rigidity

The muscular rigidity or hypertonia is also very variable in degree but is always present. In cases of moderate severity it is easily recognizable at all times. In mild cases little rigidity may be detected if it is possible to examine the patient lying at rest, but as soon as he makes an effort it is distinctly manifest. It affects all muscles of a limb or of a segment of a limb and causes resistance to passive movements in all directions. It has not the selective distribution found in the spasticity of hemiplegia. In some cases rigidity is constant and marked and here the movements are more restricted, slower and longer in their evolution.

Walking

The tonic muscular spasm in the lower limbs usually causes the patient to walk on his toes with his legs strongly adducted. Walking is jerky, with a to-and-fro rotatory movement of the body, and is accompanied by spasmodic movements of the arms and face. One or both arms may be held abducted, flexed and hyper-pronated. In slight cases the tendency to rise on the toes produces a jaunty effect. When severe spasms occur, the patient may have great difficulty in keeping on his feet and in the progressive cases walking eventually becomes impossible because of the flexor spasms of the lower limbs.

Mental disturbances

Mental impairment is usual in cases of congenital double athetosis. With the acquired and progressive syndrome some disturbance of the mentality ensues. It is first evident as an emotional change and later as a childish 'simplicity'; severe deterioration of the intellectual functions in the later stages has been described.

Voluntary power is as a rule normal, but the performance of any voluntary movement may be, and usually is, severely interfered with by the involuntary movements and muscular rigidity. There are no disturbances of sensation. The reflexes are normal, but there may be difficulty in eliciting some of the tendon-jerks because of continuous spasm of the muscles concerned.

Plantar reflexes

The plantar reflexes are flexor, but in some cases the stimulus applied to the sole of the foot excites an athetoid spasm in which dorsiflexion of the great toe shares. This slow tonic movement should be distinguished from the quicker phasic movement of the true plantar reflex. In occasional cases of the congenital group, pyramidal and extra-pyramidal disorders co-exist and in such instances the plantar reflexes are extensor.

(4)—Differential Diagnosis

From chorea

Double athetosis is frequently mistaken at first sight for chorea and while the patient lies in bed the distinction may be difficult to make. But when the patient walks, evidence of muscular rigidity is apparent in the posture of his lower limbs or of all his limbs, and the accompanying irregular spasmodic movements in his upper limbs are obviously slower than the movements of chorea.

From hysteria

The other common mistake is to regard the disorder as hysterical. This is not likely to occur with the congenital cases, but is frequent in the early stages of the acquired cases. The tic-like movements of the face, the irregular and somewhat childish manner of articulation and the jaunty quality in the gait all contribute to this error, and the absence of every abnormal physical sign that is known to have an organic cause confirms the examiner in his mistaken view. There is no criterion by which the differential diagnosis can be made that is applicable to all cases, but acquired double athetosis usually begins at an age at which hysterical manifestations of a similar nature are extremely rare; hysterical symptoms, when they do occur at this age, usually begin abruptly in consequence of a fright or other evident emotional disturbance, whereas the onset of double athetosis is very gradual and without apparent cause.

Wilson's disease

The disorder may be due to Wilson's disease (progressive lenticular degeneration). In that event evidence of this disease will be given by the history of jaundice, signs of enlargement of the liver, pigmentation of the edge of the cornea, and possibly by the occurrence of similar symptoms in other members of the patient's family.

(5)—Treatment

No treatment has any decided effect on the spasms. General sedatives may be tried, and in particular hyoscine may be given a trial in the same manner as has been suggested for simple athetosis.

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ATHLETICS

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AND

ATHLETIC INJURIES

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Reference may also be made to the following titles:

DISLOCATIONS AND FRACTURES
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MASSAGE

I.—ATHLETICS

1.–THE HEART AND SPORT

114.] Medical practitioners are naturally regarded as authorities upon the possible dangers which may follow violent exercise. Their knowledge of physiology enables them to understand such physical and pathological changes as may occur: but such knowledge must be supplemented and qualified by clinical experience.

For instance, estimation of the work demanded of the heart during violent exercise may suggest that strain might result; and it is not easy to avoid such a bias. The output of the heart, during rest, is approximately a gallon per minute; the maximum output during extreme exertion has been estimated at 37·6 litres, approximately 8 gallons per minute with a cardiac rate of perhaps 172. This colossal achievement is a tribute to the efficiency of the muscular pump, but doubt inevitably arises whether such a burden should be imposed on the heart and if it can be undertaken with safety. Yet all cardiologists who have studied 'heart strain' agree that excessive exercise cannot permanently disable the healthy heart; and that although a certain amount of 'stress' must be expected, it is not of any significance. The heart, by its large measure

Heart strain

of reserve, is defended by the breakdown of less vital structures. When the demand upon it is excessive, it is the full supply of blood to the muscles which will fail and not the heart.

Other causes of 'heart strain'

The cardiac disabilities attributed to exceptional efforts can be explained in various other ways. Some are individual peculiarities mistaken for pathological conditions. The majority are disturbances of adolescence for which there are abundant other causes, such as dyspepsia, insufficient sleep, the worry of lessons and of examinations, unrecognized mild toxaemias, the nervous strains and depressions of puberty, and perhaps masturbation. Symptoms of exhaustion from one or more of these are blamed on the heart, on account of the large amount of exercise which the schoolboy is expected to undertake. If all symptoms coming on after severe physical effort are accepted as evidence of a 'strained heart', it is not surprising that this diagnosis is frequently made.

Symptoms of 'heart strain'

The usual symptom of so-called strain is excessive exhaustion after physical exercise. Sometimes the boy is pale, giddy, nauseated, with a pulse too rapid, and very conscious of this. Faintness after an effort is a relatively innocent phenomenon; the heart is momentarily deprived of its supply by the flow of blood from the capillaries into the depleted veins of the abdomen, and the blood-pressure falls steeply and rapidly. On account of the symptoms the individual may be condemned to a life of distasteful restrictions and inactivity, although the best corrective for instability of the circulation is not sedulous care directed to the heart, but encouragement and exhortation to graduated exercise combined with attention to habits and hygiene.

Significance of murmurs

It is unnecessary to dwell upon physiological peculiarities. The time has passed when cardiac irregularity was an ill-defined and unclassified *mélange*. Senior physicians will recall youths with sinus arrhythmia who were rigidily confined to bed until regularity had been re-established. Few are now unable to differentiate the forms of irregularity which matter from those which can be ignored or are even regarded as the hallmark of a healthy heart. There is still difference of opinion about the importance to be attached to cardiac bruits, although even here broad criteria are fairly well established. Haemic or functional murmurs of unknown aetiology, but apparently of negligible significance, are usually ignored in the absence of any obvious cardiac embarrassment.

When confronted with unmistakable valvular disease the responsibility of the practitioner is greater, and he may feel some anxiety in deciding whether the patient's interests are best served by forbidding exertion, or by allowing him, with reasonable precautions, to take some exercise. Even when an organic lesion is present, how often has cardiac damage from over-exertion been unequivocally observed? It is difficult to say how far the normal vital processes of deterioration, progressing sclerosis and similar conditions are enhanced and aggravated by activity, or retarded by rest. Indeed, it is not certain that exercise does not retard such deterioration.

A moral duty

The practitioner's responsibility is as heavy when he forbids games to a growing boy as when he encourages mild exercise for a boy whose heart is known to be faulty. An adolescent who grows up with a belief in his physical inferiority is in danger of warping his character. The suggestion of perpetual risk to life, which undue restriction introduces, must inflict untold moral damage; for to the layman cardiac imperfection means 'heart disease' and the red flag of danger and sudden death. Further, it is difficult to keep a schoolboy from the vicious habits bred of idleness when the games that his fellows share are forbidden him. It becomes the duty of the school and its masters to find a substitute for sport for such boys, and this is by no means easy. It is not surprising that an enthusiast asked, 'What are a few accidents or over-strains compared with broken-down morals, weakened will and disturbed intellect?'

Effort syndrome

The civil practitioner is less concerned than his colleague in the Services with the difficulties of 'effort syndrome' or 'neuro-circulatory asthenia'. During and shortly after the Great War this disorder, under the topical description of 'soldier's heart', exercised the minds of investigators, and incurred the expenditure of millions of pounds. The obligations of the practitioner will in general be met if he recognizes that there are individuals who are constitutionally ill-adapted physically for exertion, and that, with very few exceptions, their disability is irremediable. As a physiologist he may be interested to speculate upon the cause and situation of the constitutional imperfection. It may be ill-developed coronary vessels or poor contractile power of the cardiac muscle. The inefficient athlete convicted of a 'yellow streak' may be unfairly condemned; the yellow streak may be not in his spirit but in the fibres of his heart muscle; an over-active brain may fail to protect the heart from uneconomical activity. A large number of theories have been advanced on physical, psychical, endocrine, or toxaemic lines to explain the symptoms.

Constitutional inefficiency

Toxic myocarditis

How far is the myocardium susceptible to the influence of microbic and other toxins apart from those of rheumatic fever and diphtheria? I am very doubtful about the admission of any others. Certainly the subject of an acute infection is incapable of exertion and sometimes suffers from prolonged lassitude and premature fatigue. But this is due to insufficiency not of the heart but of the vasomotor system. It may not be of any practical importance where the lesion is placed, but it may be of considerable psychological importance to exonerate the heart. And there may also be some importance from the therapeutic point of view, in that graduated exercise, and not complete rest, is the quicker route to recovery.

2.–TUBERCULOSIS AND SPORT

The rare event of pulmonary tuberculosis attacking a distinguished athlete is sometimes advanced as evidence of pulmonary strain: but the tuberculous diathesis may be accompanied by a flair for athletics, I have seen a few examples confirming this impression. That any undue susceptibility can be due to indulgence in athletics I cannot believe, and it would be exceedingly difficult, if not impossible, to eliminate all other possible factors.

3.–THE KIDNEY AND SPORT

Albuminuria

The association of albuminuria with physical effort is now too well known to cause misgivings. A study of the subsequent career of boys originally believed to be future victims of nephritis has established beyond doubt the innocence of the condition. The explanation of the albuminuria of exercise is still incomplete. The kidney is extremely sensitive to want of oxygen; slow deep breathing for half an hour may produce albuminuria. Oxygen-want, however, is probably not the only element; some physical factor in the blood or glomerular walls may also be concerned. My experience of seasoned adult track athletes is that albuminuria is rare and the presence of casts exceedingly rare even when such extreme efforts as running a half mile in world's record time or walking 8¼ miles in an hour have preceded the examination. William Collier, however, found albumin in quantity and sometimes casts and blood in the urines of oarsmen, and medical officers have reported its appearance almost universally in schoolboys after even comparatively short runs. Such observations suggest that either the nature of the exercise—the mechanical factor in the case of rowing—or instability of the vasomotor system may be responsible. Yet in a recent conversation with an investigator whose results are not yet published, I learnt that hardly a single member of an inter-university boat-race crew displayed albuminuria after completing a course. Such an observation, if confirmed, would be very difficult to reconcile with Collier's findings since modern boat-racing hardly differs from that of forty years ago. The subject is, therefore, still one for laboratory investigation although clinically no importance need be attached to the occurrence of albuminuria after exercise.

Glycosuria

Transient glycosuria is infrequent; its occurrence may be explained by the great increase which is known to take place in the amount of adrenaline in the circulation.

4.–FATALITIES FROM EXERCISE

From heat-stroke

The only serious potential risk to life in violent exercise is that of heat-stroke resulting from prolonged exertion under conditions unfavourable to heat loss. This danger does not often arise in temperate climates, but on rare occasions the possibility should be remembered. When medical men are invited to participate in the absurd traditional precaution of examining competitors before a marathon-race, they should point out that no amount of previous examination can detect those likely to be particularly susceptible to over-heating.

From organic disease

Apart from the few fatalities which have occurred from heat-stroke, deaths from exertion have occurred in those suffering from arteriosclerosis in whom the slightest additional stress may lead to rupture of the vessels.

In younger subjects when the effort has been of the most trivial character, vagal inhibition from shock has been thought to be responsible.

5.–THE NERVOUS FACTOR IN SPORT

Although the physical risks of violent exercise have been critically considered, some danger inherent in severe athletic competitions must be admitted. A paper published in 1876 contained the alarming assurance that 'if any psychologist will take the trouble to trace out the history of each of our prominent pedestrians he will discover that a very large proportion of them have been subject to some form of madness'.

The worst that can be said of the modern athlete is that he may become neurotic about his games, and possibly neurasthenic. This neurosis is not so much the effect of exertion as the outcome of competition, of public adulation, of the realization that he is in the limelight, and of the fear of failure. It is found more especially in men who have to make intensive and explosive efforts rather than in the phlegmatic man of endurance. The continuous overflow of nervous impulses to the muscles, the complex processes involved in co-ordinating skilled movements and focusing attention, the excitement, apprehension, anxiety and judgement exercised for long intervals suggest that strain produces a lesion in the nervous system and not the heart.

6.–GIRLS AND SPORT

Finally, a few words may be added on the subject of athletics and high-grade competitions for girls and young women. It seems that any objection on the ground of nervous excitation which applies to men, applies with greater force to women, whose nervous systems, traditionally at any rate, are more susceptible. In addition we should look askance at the diversion of energy from channels for which it is specially required.

II.—ATHLETIC INJURIES

115.] Athletic injuries may occur as the result of: (1) direct trauma, in which event bruising of the tissues is frequently the noticeable feature; (2) indirect trauma, in which event ligaments and muscles are over-stretched or torn. Thus a twist or movement may take place so suddenly that the muscles of the part fail to contract in time to prevent overstretching or tearing of the tissues associated with a joint.

1.–PATHOLOGY

Effusion

An injury is at once followed by a traumatic effusion which may be an exudation from intact blood-vessels or a haemorrhage from torn or otherwise injured blood-vessels. Such an exudate forms a framework on which new fibrous tissue can grow and eventually take the place of the damaged structure. Unfortunately the amount of traumatic effusion may far exceed that required for sound repair of the tissues. This superfluous effusion tends to form adhesions and thickenings between the damaged structures and the neighbouring tissues, and favours the formation of a weak, contracting scar.

Haemorrhage

Sometimes a pool of blood collects in a damaged structure as the result of haemorrhage from a torn vein; as long as this blood remains fluid there are few, if any, symptoms apart from slight tenderness; but as soon as the fluid part of the blood is absorbed and the more solid portion consisting of fibrin and cells is left, muscular action will cause pain by squeezing the solid mass and stimulating the sensory nerve-endings of the part. Several days or even weeks may elapse before this pain is felt.

Contraction

A fundamental character of fibrous tissue is its tendency to contract; when therefore an injured structure is replaced by fibrous tissue, shortening and contraction will naturally occur unless this is prevented.

Absorption of effusion

A traumatic effusion is continually undergoing absorption through the lymphatic and venous circulations of the part. If an injured structure is rested entirely, the effusion tends to consolidate around and in the damaged structure, as the returning circulation has been disturbed by the injury. One of the objects of treatment therefore must be to disperse the excess of traumatic effusion into an area where healthy lymphatics and venules can pick it up. With movement effusion tends to spread and its direction is influenced by three factors: by gravity (i.e. fluid tends to filter down to the most dependent part), by the configuration of the enclosing fascial compartments, and by muscular action.

Bruising

Sometimes the traumatic effusion, as it is percolating or seeping through the tissues, is not absorbed by the time it has reached the dermal lymphatics; it may then become apparent some distance from the site of injury as a superficial bruise or discoloration. With movement, traumatic effusion tends to spread, but in some cases as it is thrown off by muscular action from the surface of a damaged muscle it consolidates in places where there are no muscles, called 'dead areas'. The thickenings caused by this consolidation are very tender on pressure and may cause much aching pain. The formation of tender thickenings and adhesions round a joint often causes swelling on movement of the joint.

It must be realized that swelling, provided it does not become so excessive as to overload the returning circulation, is necessary. Adhesions and thickenings cannot be absorbed until they are disintegrated and softened, and movements and physical treatment, although they stir up the consolidated traumatic effusion, provide lymph and cells for its absorption. This is why a stiff joint swells after exercise; nevertheless, modified movement and appropriate physical treatment should never be omitted at this stage, otherwise the swollen infiltrated joint will only stiffen again, probably with increased limitation of movement. *Swelling*

Sometimes when a joint is sprained the true relation of the joint surface is disturbed so that there is slight but true subluxation. As the result of the injury and subsequent traumatic effusion, the muscles of the part pass into spasm and maintain this new position of the joint surfaces so that the subluxation persists. Gentle manipulation without an anaesthetic overcomes muscular spasm and reduces the subluxation, often with immediate relief of pain. *Subluxation*

2.–DIAGNOSIS

Diagnosis of an injury must be attempted by obtaining an accurate history of the way in which it was sustained. Many of the common athletic injuries give an absolutely characteristic history, a particular movement or position of the joint being responsible.

In the examination of the patient special attention should be directed to finding (i) which is the most tender point (this is very important); and (ii) which movement of the limb, active or passive, produces pain. The examiner's finger should be placed lightly over the injured part and when the point of maximum tenderness is found, its exact anatomical position should be ascertained. Radiological examination should never be omitted if there is the slightest suspicion of a bone injury. An X-ray film often reveals an unsuspected fracture; moreover, it satisfies the patient that everything possible is being done and safeguards the practitioner in the event of litigation. Fractures or graver injuries, such as tears of the brachial plexus or injuries of the kidney, are outside the scope of this article.

It is possible to classify athletic injuries in accordance with the treatment required, under the following headings:

(1) Injuries to joints:

(a) In ligamentous sprains, there is tenderness either at the attachment of the ligament, or along the line of the ligament, and an area of swelling over the ligament. Active or passive stretching of the ligament is painful but there is no synovial effusion.

(b) In sprains of the joint, in which the synovial membrane is stretched or torn, there will be definite synovial effusion and there may, at the same time, be ligamentous injury. From the point of view of treatment, however, it is essential to distinguish between these two types of injury.

(2) Injuries to muscles:
  (a) A sprained muscle.
  (b) Tearing of a few fibres of a muscle.
  (c) A ruptured muscle with no displacement of the ends.
  (d) A ruptured muscle with displacement of the ends.
  (e) Teno-synovitis.
(3) Bruising of bone. Subperiosteal haematoma.
(4) Injuries to bursae.

3.–TREATMENT

Treatment should be started as soon as the injury has been diagnosed. Its chief object should be: (i) sound repair of the damaged structure so as to avoid the formation and subsequent contraction of scar tissues with loss of elasticity of the part; (ii) early absorption of traumatic effusion so as to avoid a fibrous tissue reaction with the formation of adhesions and thickenings; (iii) prevention of muscular wasting in the neighbourhood of the injury.

(1)—Bandage, Aspiration and Support

Pressure bandage

The first procedure must be to prevent excessive traumatic effusion by the application of a firm pressure-bandage over cotton-wool or pads of felt. A bandage is more comfortable than adhesive strapping or plaster, as it permits a certain amount of swelling—which is inevitable—but will prevent it from becoming excessive: e.g. for a sprained ankle the joint is encircled with half an inch thickness of cotton-wool, and a strong domette or a Vic Sports crêpe bandage is firmly applied. The benefit derived from a pressure-bandage can be augmented by the simple procedure of raising the damaged structure, so that it is on a higher level than the rest of the limb.

Combined with pressure, local application of a counter-irritant or a soothing lotion is beneficial; e.g. (i) Scott's dressing; (ii) solution of hamamelis; (iii) magnesium sulphate compresses (a saturated solution is made with warm water and the compress applied under oiled silk and a firm bandage); (iv) lead and opium lotion; or (v) antiphlogistine (kaolin poultice).

Excess of traumatic effusion can be removed by the following methods: (i) by promoting absorption through the lymphatic and venous circulations; (ii) by aspiration and expression through a small incision if the fluid is sufficiently localized.

Aspiration of effusion

Aspiration can be carried out easily under local anaesthesia without causing much pain. Preserving the strictest asepsis, the swollen part is sterilized with spirit. A small area in the centre of the swelling is chosen and painted with iodine and anaesthetized with 1 c.c. of 2 per cent solution of procaine hydrochloride (novocain). The effusion, if still fluid, can be easily aspirated through a large trocar and cannula, or a

20 c.c. syringe with a wide-bore needle. On the other hand, if the effusion has had time to clot, it may be necessary to express it through a small incision made with a tenotome. In this event, it may be necessary to extend the incision through the deep fascia before the clot can be expressed.

Support

The important procedure of supporting the damaged structure is often omitted. It has been pointed out that one of the principles of treatment is to allow the structure to undergo complete repair. If an injured joint or muscle is allowed to function actively without support, it is certain to be strained; the associated muscles are weakened and made atonic by the injury, and have no chance of quick recovery. The mistake of supporting a part too long must not be made, otherwise the muscles will never recover fully. The best plan is to support the injured part when it is first carrying out movements with weight-bearing, and each day to remove a portion of this support until eventually it is no longer necessary. Support is best obtained by adhesive tape or elastoplast strapping. In the case of the knee-joint a firm crêpe bandage, such as the Vic Sports bandage, with an elastic knee-cap over it to hold it in place, is probably more efficacious than strapping as it allows free movement.

The available methods for promoting the absorption of traumatic effusion by the venous and lymphatic circulations are: (i) graduated movements, (ii) massage, (iii) various forms of heat; (iv) contrast baths, (v) various forms of electrical treatment.

(2)—Movements and Manipulation

The sequence of movements is from complete rest, through gentle movements without weight-bearing, to active movements with weight-bearing. Absolute and complete rest is not now advocated in the routine treatment of injuries, but must be observed in exceptional cases. For example: (i) in injuries accompanied with complete rupture of a nerve; (ii) in injuries following dislocation, for 2 or 3 days; (iii) in injuries to the elbow-joint, for a week; (iv) in fractures; the site of fracture is completely immobilized, but the overlying muscles moved as soon as possible; (v) in certain cases of teno-synovitis, especially those involving the extensor muscles of the wrist; and (vi) in rupture of a muscle with displacement of the ends.

In cases of joint injury, when there is a synovial effusion, rest from weight-bearing is necessary otherwise the synovial membrane will be continually stimulated and the swelling of the joint maintained.

On the other hand, gentle movements up to the point of producing pain, can be carried out with the limb resting on a couch. The object of these movements is to spread the traumatic effusion into areas with normal lymphatic fields, and also to help to restore the tone of the muscles which has become impaired by the injury.

In the treatment of ligamentous injuries, or injuries to muscles, active movements with weight-bearing can be allowed, provided that the injured structures are supported. The reason is that in these cases a secreting membrane is not involved, as it is in a joint injury.

Remedial exercises

The patient with an injury should always be given exercises to carry out at home. Such exercises can be prescribed with or without weight-bearing according to the nature of the injury and the stage of its recovery.

Manipulative movements

Passive movements should never be given or recommended, as they are inclined to irritate the damaged structure and so to increase the traumatic effusion. On the other hand, during the stage of recovery gentle manipulative movements are essential to prevent contraction of the torn structure, which is so often the sequel to an injury.

Gentle manipulative movements are entirely different from passive movements, for in such manipulative movements the first principle is to apply tension and counter-tension, so that the joint surfaces are separated. For this purpose tension is applied by the operator's hand, which, placed below the joint, pulls away in the long axis of the limb, while at the same time counter-tension is applied by the operator's other hand or by an assistant pulling in the opposite direction.

The second principle in manipulation is to carry out the involuntary movements of the joints, while still applying tension and counter-tension. The operator moves the joint in an antero-posterior direction, postero-anterior direction, in rotary and side-bending directions. These movements are out of the patient's control and cannot be carried out voluntarily.

The third and final manœuvre in manipulation is to perform the voluntary movements while still applying tension and counter-tension.

(3)—Massage

Many orthopaedic surgeons are tending to give up massage in the treatment of injuries. Böhler maintained that it was not necessary if the injured structure was moved actively, as this procedure would help absorption of the traumatic effusion and prevent the formation of adhesions and thickenings.

Types of massage

There are various types of massage: effleurage; frictions (deep circular movements performed by the thumbs around the joints); kneading; and tapotement (including hacking and clapping).

Massage is employed with these aims: (i) to promote venous and lymphatic circulation towards the heart; (ii) to diffuse the traumatic effusion from the damaged structure into the healthy tissue so that it can be more easily absorbed; (iii) to break up the thickenings caused by the consolidation of lymph and blood in the tissues.

The masseur must endeavour to visualize the exact pathological condition in order to apply just the right type of massage to each injury. In the early stages of recovery gentle massage only will be tolerated, but if it is necessary to break up tender thickenings, firm and deep massage must be employed in spite of its causing the patient a certain amount of pain.

(4)—Heat

Heat can be applied either by hot compresses or by heat lamps; the infra-red heat rays are the most penetrating. Heat is often combined with massage or faradic contractions.

(5)—Contrast Baths

These consist of immersing the damaged limb in alternate hot and cold water baths for thirty seconds each. The effect of this is alternately to dilate and constrict the blood-vessels of the injured part, thus facilitating absorption of traumatic effusion.

(6)—Electrical Stimulation

The methods in treatment so far advised can be performed by any medical man without any modern electrical apparatus. There are several forms in which electricity can be used with great advantage in helping absorption of traumatic effusion and restoring the tone of injured muscles.

(*a*) *Faradic Contractions*

First in importance is the stimulation of the muscles in the neighbourhood of the injury by the faradic battery. Each muscle can be picked up separately and stimulated to contract. The effect of this is to prevent adhesions between adjacent muscles and neighbouring structures. The artificial stimulation of muscles following injury is in the early stages often preferable to active movements, especially with weight-bearing, as the muscles are often so atonic that active movements without further strain are impossible.

Faradic contractions must be given by the method set out by Morton Smart and, as an example, faradic treatment of the right knee-joint will be described. The description, *mutatis mutandis*, also applies to the left knee.

Treatment of right knee

The patient reclines comfortably on a low couch with the operator on his left-hand side, facing him. Two electrodes from the Smart-Bristow coil are covered with lint and one is placed at the back of the right thigh in contact with muscles. The other, or active, electrode is held between the thumb and index finger of the left hand. It is now placed on the quadratus internus 2½ inches above the knee. The machine is set working and with the operator's right hand the controlling core is pushed in and withdrawn so as to obtain an even contraction and relaxation of the muscle. This procedure is repeated five to ten times; then the active electrode is changed to stimulate the quadratus externus. In this way each muscle around the knee-joint is made to contract, but is never over-stimulated so as to become fatigued. Directly after injury, from ten to fifteen minutes' treatment may be sufficient, but after a few days a full treatment may last up to half an hour. Every muscle has its own rate of contraction and relaxation, but in cases of injury this rate is altered; in some cases the muscles may contract and relax thirty times a minute and in other cases as often as fifty times a minute. In giving faradic contractions any mechanical device which controls the number of contractions of the muscle is absolutely wrong in principle. The use therefore of instruments such as metronomes, myotropes, and gramophones, designed to avoid the necessity of surging the muscle, is equally wrong. Complete relaxation must be obtained between each contraction otherwise spasm and cramp are produced with definitely detrimental effect.

(*b*) *Galvanism* (*Direct Current or Ionization*)

Small currents of about 3 to 5 milliamperes with the anode over the point of injury give the best result. With the direct current, traumatic swellings are reduced in size by the passage of electrical ions through the blood-stream, thus aiding absorption.

Galvanism to right knee

To treat the right knee by galvanism, two large pads consisting of eight layers of lint are placed over the two electrodes. The anode or positive electrode is placed over the inner side of the right knee, while the cathode or negative electrode, which has been soaked in weak saline solution, is placed over the outer side of the middle of the thigh. A weak current of 4 milliamperes is turned on for 15 minutes. For patients sensitive to even this amount of current weaker currents must be used.

(*c*) *Diathermy*

Injured structures can be heated by means of an alternating current of high frequency. The effect of this is that the blood-supply to the injured joint or muscle is increased and absorption is promoted.

Diathermy to knee

To apply diathermy to the knee, the two electrodes of perforated lead-sheeting connected to the diathermy machine are firmly strapped on opposite sides of the joint. Care must be taken that there is perfect apposition between the electrode and the skin. The current must be so carefully controlled that only a warmth is experienced by the patient. If these precautions are not taken a diathermy burn will result.

4.–CLASSIFICATION OF INJURIES WITH THEIR APPROPRIATE TREATMENT

(1)—Joint Injuries

(*a*) *Ligamentous Injuries*

The two joints in which ligamentous injuries most commonly occur are the ankle and the knee. A sudden inward twist or jerk of the foot ruptures the anterior band of the external lateral ligament of the ankle-joint; the foot swells in the region of this ligament and any attempt at inversion of the ankle produces extreme pain.

Ankle

Knee

Injury to the internal lateral ligament of the knee is produced by a sudden abducting force applied to the leg when the knee is partly flexed.

Very often the attachment of the ligament is torn away together with a scale of bone. For this reason careful X-ray investigation is most important. In distinction from cartilage injuries, rotation at the knee-joint plays no part in the production of this injury.

External lateral ligament of ankle

Treatment for external lateral ligament strain is as follows: (i) the ankle is supported by strapping with the foot dorsiflexed and everted so as to relax the ligament; (ii) active movements with weight-bearing are allowed; (iii) massage given by the patient over the strapping to ensure that the products of injury are not settling into tender thickenings in 'dead areas'. After four to five days the strapping is removed and the ankle-joint, subastragaloid and mid-tarsal joints are put through their full range of movement by gentle manipulation. It may be necessary to restrap the joint but the strapping should be removed every two or three days.

If X-rays show that a scale of bone has been torn off, or if the periosteum is injured, early rest is essential, for massage in such circumstances might encourage inflammation and the production of an excess of new bone. The correct treatment is to strap the foot in dorsiflexion and in eversion for a fortnight and during this period apply no other treatment.

Internal lateral ligament of knee

In cases of injury to the internal lateral ligament of the knee-joint four to six weeks may elapse before the joint feels normal, and during this period it will be necessary to give faradism, massage, and diathermy in order to accelerate the absorption of traumatic effusion and prevent contraction of the ligament.

(*b*) *Sprains*

Sprains of the joint itself with synovial effusion in which the ligaments may or may not be damaged. The synovial membrane is definitely inflamed and sensitive.

Treatment must therefore consist of: (i) pressure-bandage over wool for the first two days; (ii) gentle active movements without weight-bearing until all effusion has disappeared; (iii) contrast baths; (iv) gentle remedial exercises and manipulations; (v) faradic contractions; (vi) ionization or diathermy.

(*c*) *Dislocations*

Treatment must consist of: (i) reduction of dislocation followed by X-ray examination; (ii) firm bandage over wool; (iii) after three days' complete rest, the joint is treated gently on the lines of a sprain. No weight-bearing or lifting is allowed for three weeks but by that time as the result of gentle active movements the range of movement will have been restored to normal.

(*d*) *Internal Derangements*

Internal derangements include torn, crushed or displaced cartilage. If there is true locking and the joint is constantly giving way, operative removal is the only course.

(*e*) *Chronic Joint Injuries*

(i) A stiff joint shown by limitation of movement. Treatment should consist of a manipulation under an anaesthetic followed by daily physio-therapeutic measures.

(ii) Joint weakness due to muscular wasting from injury. In these cases the joint is liable to give way because it has lost its muscular support. Treatment consists of remedial exercises and daily treatment of the muscles by faradic contractions.

(2)—Injuries to Muscles and Tendons

(a) Strain of a muscle.

(b) Rupture of a few fibres of a muscle. These two degrees of injury can be treated by the same method: by (i) support; (ii) faradic contractions and remedial exercises; (iii) massage under heat; (iv) active movements with weight-bearing; (v) diathermy and ionization.

(c) Complete rupture of a muscle or tendon, without displacement. Treatment should consist of: (i) application of a firm plaster of Paris cast or firm strapping to the injured part; (ii) movements without weight-bearing after three days; (iii) after ten days removal of the cast or strapping and daily treatment of the muscles by gentle faradic contractions. This is continued for a fortnight and gradually after this period more and more strain can be brought to bear on the muscle. An example of this type of injury is rupture of the gastrocnemius.

(d) Complete rupture of a muscle or tendon with displacement. These cases should be operated on unless there are grave constitutional disorders which make operations dangerous.

(e) Avulsion of the tendon of origin or insertion with a flake of bone. Examples of this are: (i) Codman's supraspinatus tendon avulsion; (ii) tearing of the insertion of the triceps from the olecranon; (iii) tearing of the extensor tendons from the terminal phalanx producing a mallet finger; (iv) avulsion of the adductor longus muscle from the pubic ramus. Often, by placing the limb into a certain position, the fragments can be brought into close apposition with the bone from which it has been torn, e.g. abducting the arm in supraspinatus tendon avulsions. When, however, there is the slightest doubt, the avulsed tendon should be exposed and replaced again by suturing.

(f) Teno-synovitis from acute strain. This condition is often associated with a sprained joint. Treatment consists of support, faradic contractions, massage under heat, and ionization. If the condition is allowed to become chronic, adhesions take place between the tendon sheath and the tendon itself, leading to pain on movement. These cases are very difficult to cure quickly. After the acute stage, treatment consists of deep massage, manipulative stretching of the tendon, and ionization.

(g) Teno-synovitis from chronic strain. There is often a superadded toxic element on top of the strain, and physio-therapeutic measures make the condition worse. Treatment consists of eradication of the septic focus, complete rest to the tendons for ten days to a fortnight, then strengthening of the muscles by faradic contractions and exercises.

(3)—Bruising of Bone

A typical example of this injury is a kick on the shin. The condition produces an excruciatingly tender periostitis over the injured area if left to absorb unaided. Treatment should consist of heat, massage and diathermy.

(4)—Injuries to Bursae

When due to direct trauma treatment should consist of: (i) aspiration; (ii) protection of the bursae from further injury; (iii) direct current. Recurrent cases may require operative removal.

In these recurrent cases a septic focus should be suspected, and eradicated if found.

5.–COMMON ATHLETIC INJURIES WITH THEIR APPROPRIATE TREATMENT

Tennis Calf or Sprinter's Leg. This is very common. The patient often experiences a sudden sharp pain in the back of the leg when he is running or leaping. It is often described as resembling a blow from a stick or a shot, and is usually caused by a snapping of a few fibres of the inner head of the gastrocnemius, or the Achilles tendon. Bristow demonstrated that in sixteen patients operated on, the plantaris muscle was in each case intact. Treatment consists of a firm strapping support put on with the heel elevated. This is left for three days and then gentle exercises, faradism, and massage are started. Cases in which there is complete rupture of the Achilles tendon may require operation or complete rest in plaster of Paris. If the latter course is adopted, the plaster of Paris is left on for three weeks, and is then bivalved to permit the application of gentle faradism to the muscles. In the intervals of such electrical treatment the plaster should be restrapped and every care should be taken to prevent dorsiflexion.

Bowler's Arm. This condition occurs after a spell of fast bowling. The patient finds that all movements of the arm from the shoulder down, particularly that of flexion, are painful. On examination, there is tenderness over the coracobrachialis or the long head of the biceps, or occasionally in the supraspinous fossa due to a strain of one or other of these structures. The treatment is as in other injuries to muscles, e.g. gentle active movements, faradic contractions, and massage. The bowler should be encouraged after ten days to start gentle bowling at the nets. This should be gradual, increasing until he is able to bowl fully out.

There is another type of bowler's shoulder, namely, the detachment of the tip of the greater tuberosity of the humerus by the pull of the supraspinatus tendon. The detached fragment, drawn away from its original bed, may be seen by X-rays. It must, however, be distinguished from ossification in the supraspinatus, which is by no means uncommon as a sequel of previous bruising or strain of the muscle. An attempt should be made to re-incorporate the detached chip with the main body of the bone by putting the patient's arm in a shoulder abduction splint.

Rugby Shoulder. Falling at Rugby football or any other strenuous game may produce a sprain or subluxation of the acromio-clavicular joint with persistent pain and swelling at the outer end of the clavicle.

Tennis Elbow. There are three types of tennis elbow: (i) sprains of the wrist extensors from their origin at the external condyle; (ii) sprains of the radio-humeral joint; (iii) painful deposits on either side of the olecranon process. Often tennis elbow starts as a strain; then, if the patient is rheumatic or has an infected tooth or tonsil, the circulating toxins may settle in the injured tissues. Most of these cases respond to a forcible manipulation under an anaesthetic, followed by massage over the tender area—along the external lateral ligament—with faradic contractions to the wrist extensors and remedial exercises. Many take from four to six weeks to recover absolutely and during the recovery stage the pain varies a great deal from day to day, but the joint will recover if treatment is continued sufficiently.

Golfer's Elbow. A similar but less severe injury occurs in golfers, over the internal or medial condyle of the humerus, resulting from a strain of the muscles of the forearm. Treatment consists of massage, remedial exercises and faradic contractions to the wrist extensors.

Rugby Wrist. Handing off with the ulnar side of the hand leads to bruising of the triangular fibro-cartilage near the styloid process of the ulna. Owing to bruising of the cartilage, these cases are often resistant to treatment, but if deep massage combined with diathermy is given, every case will recover in three weeks.

Wicket-keeper's Finger. A wicket-keeper's finger can be injured in the following ways: (i) By a strain of one of the inter-phalangeal joints. Such a sprain is very resistant to treatment; it may be weeks before the swelling of the joint subsides, and still longer before the joint is capable of full movement. (ii) By the tearing of a flake from the dorsum of the terminal phalanx. This injury (mallet finger) arises from a blow on the end of the digit by a cricket ball producing forced flexion of the terminal inter-phalangeal joint. The small piece of bone, to which the extensor tendon is attached, is torn off; the patient can no longer extend the terminal phalanx and the finger assumes a position of slight permanent flexion at the end joint. Treatment is disappointing as the small piece of bone does not always become reunited with the body of the phalanx. The application of a splint is usually advised, to hold the terminal joint in a position of hyperextension in order to secure this union. If treated properly by adequate rest in the hyperextended position in the first instance, most cases progress perfectly well. The splint must remain undisturbed for four weeks. In late cases, it is worth while attempting immobilization in hyperextension for even as long as three months after the injury. If the joint remains painful, an arthrodesis of the terminal phalangeal joint should be performed.

Rider's Strain. This term comprises a number of injuries. It is often caused by a horse refusing to take a jump, with the result that the rider's body is thrown violently to one side; as he attempts to keep his seat some fibres of the adductor longus muscle are torn. The muscle may be completely ruptured or it may be left swollen, painful and stiff from haemorrhage into its substance as a result of the tearing of some fibres. Such injuries have been considered above (see p. 234). Often a small piece of the pubic bone is torn away with the attached tendon, and periostitis, which may be persistent, develops at the site of the injury.

Treatment consists of rest with the muscle fully relaxed and attempts to disperse any effusion. As the patient will find riding painful, it must be avoided until the injury has completely healed; this requires three to six months. Treatment in mild cases entails rest from riding, but should include gentle active movements, massage and faradic contractions to the adductors. As soon as the swelling has subsided, the patient should be instructed to practise gripping a chair between his legs. Usually it is possible to allow the patient to ride again within ten to fourteen days, even in moderately severe cases.

Injury to the Knee-Joint. This is one of the commonest injuries met in sport. When such an injury occurs the first necessity is to control any effusion, and the next, to make an accurate diagnosis of the structure which has been damaged. The clearest distinction must be made between ligamentous and synovial injuries. In some cases the history of the injury is characteristic, as in the following two common lesions.

A severe strain is thrown upon the inner side of the joint by a weight falling across the outer side when the knee is flexed. This is likely to cause a simple tear of the internal lateral ligament, and on palpation the most marked tenderness is found well over the lower attachment of the ligament to the tibia and away from the joint line.

The player tries to kick a ball with the inner side of his foot and, as he makes the attempt, his foot is arrested against something more solid than the ball, e.g. a player on the ground; or someone charges him and he twists his body and thigh inwards while his foot rotates outwards. In either event relative outward rotation of the tibia on the femur occurs in a position of flexion and as much abduction as the internal lateral ligament will allow. The patient falls to the ground with knee locked and very soon effusion occurs. In such cases the internal meniscus is almost invariably torn. If the injury is seen on the field it can often be diagnosed at once and the deformity reduced by flexion, by rotation inwards and outwards, and by forcible extension. If the patient is seen some time after the injury, diagnosis rests upon the history, upon the locking of the joint and upon the fact that the point of maximum tenderness is at the level of the joint line, midway between the anterior border of the internal ligament and the medial border of the patellar tendon.

Bruising of the Infrapatellar Pad. The infrapatellar pad lies behind the patella and overlaps it slightly on either side, and is liable to nipping or bruising on violent rotary movements of either femur or tibia with extension at the joint. This injury is usually confused with rupture of the internal semilunar cartilage. The treatment is massage over the pad of fat, faradic contractions to the quadriceps to prevent wasting, and diathermy through the pad of fat.

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AUTONOMIC NERVOUS SYSTEM

See Sympathetic and Parasympathetic Nervous System

AUTOPSY

See Post-Mortem Examination

AVELLIS'S SYNDROME

See Cranial Nerve Affections

AVIATION

(MEDICAL EXAMINATION OF PILOTS)

By Wing-Commander T. S. RIPPON, O.B.E., R.A.F.M.S. (Retired)

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1.–GENERAL

116.] Certain definite physical and mental qualities are essential for a successful career as an air pilot, and individual differences in ability to learn the art of flying can be correlated with variations in these characteristics. During the War examinations of successful pilots and of individuals subject to fainting and giddiness in the air showed that flying efficiency—which included ability to stand lack of oxygen at high altitudes, and prolonged nervous strain—depended on (1) the normal vital capacity of the lungs, (2) the stability of nervous control of the respiratory and circulatory systems, (3) the reactions of the vestibular mechanism, and (4) the visual judgment of distance.

In acquiring the art of flying, the sense of vision and the power of correct neuromuscular co-ordination of the limb muscles are also of the greatest importance. In respect of vision, not only good visual acuity, but also well-balanced eye muscles for judging distance on landing are required.

The 'Physical Efficiency Tests' evolved by the Air Medical Investigation Committee and employed as an adjunct to the clinical examination of the heart, lungs and other organs, provide a satisfactory method of assessing suitability for a career in flying, and have the following advantages: (*a*) They are simple, do not require elaborate apparatus, and take a minimum of time. (*b*) They afford the examiner a measure, which can be compared with standard figures, of the safety of the pilot when exposed to extreme fatigue, lack of oxygen at high altitude, and prolonged nervous strain. It is claimed that, when properly carried out and assessed, these tests indicate individuals who, when tired, are liable to errors of judgement. (*c*) They have a wide scope, and can be done successfully both by the average normal schoolboy of seventeen or eighteen and by an adult of fifty, provided he has not impaired his physique by an unhealthy life. (*d*) They enable the examiner to grade pilots as average, super-fit, or alternatively as unsuitable types or potential 'crashers'.

By repeating the tests at intervals of six months changes in the functional efficiency of the human machine can be measured, and useful advice may be given when early signs of deterioration are noted. In this way the flying life of civilian and military pilots can often be prolonged, and the safety of passengers and aircraft increased.

2.–SCHEME FOR THE EXAMINATION OF PILOTS

Object of medical examination

The object of the medical examination is to prevent accidents due to the personal factor, by detecting those individuals who have some physical defect which may cause them to lose control or make errors of judgement.

The procedure recommended is as follows:

(1) A consideration of the history of any serious illnesses or accidents, with a general assessment of mental aptitude for flying. The family history is also investigated. (2) A general physical examination for organic disease of the heart, lungs, kidneys, central nervous system. (3) Special physiological tests for stability of the circulatory and respiratory systems in regard to high altitude and flying strain. (The Physical Efficiency Tests.)

(1)—Personal and Family History

The preliminary interview is designed to obtain a history of previous illnesses and after-effects, and to assess aptitude for flying. The examiner should question the candidate from three points of view: (*a*) Has he ever had any illnesses which would make him a 'bad life' from an insurance point of view? (*b*) Has he ever had any symptoms which would make him a risk from a flying point of view? (*c*) Is he likely to be successful as a pilot and withstand the strains incidental to flying, e.g. fog, darkness, cross-country flying, and accidents?

The following list has been found by experience to be the most useful as a guide in obtaining a history of previous illnesses. Is there any history of: nervous breakdown or 'nerve trouble'; severe or 'sick' headaches, migraine; fits or convulsions of any kind; sun- or heat-

stroke; head injury or concussion (including 'knock-out'); insomnia, nightmare or sleep-walking; bronchitis, pneumonia or pleurisy; consumption or suspected 'lung trouble'; asthma or hay-fever; rheumatism, rheumatic fever or 'growing pains'; frequent sore throats; diphtheria, scarlet fever or scarlatina; heart diseases, 'weak or strained heart'; fainting attacks, or giddiness; chronic indigestion or pain after food; other 'stomach or bowel trouble'; malaria; dysentery; other tropical ailments; syphilis or gonorrhoea; eye trouble or inflammation of eyelids; wearing of glasses; defective perception of colours (or in family); deafness; severe earache or discharge from ears; frequent colds in head; sea- or train-sickness; discomfort on swings, roundabouts or switchbacks; any illness or injury necessitating a prolonged rest in bed or prolonged absence from work; any illness or injury not mentioned above or any operations?

If the history given by the candidate clearly shows that he is a 'bad life', i.e. liable to some disorder, such as fainting attacks or fits, the examiner need not proceed further with the case, for if he is unsafe on the ground he is still more so when flying.

When in doubt whether or not an illness has left any ill-effects on the heart or lungs, the athletic career after the illness should be inquired into.

Nervous instability may be hereditary or due to unfortunate experiences in early life. A neurotic parent is less likely than a normal parent to have a normal child.

(2)—Physical Examination

This consists of the usual examination of the body by inspection, palpation, percussion and auscultation, and of the urine as described in the usual text-books. It would take too long, and not serve any useful purpose, to enumerate the various diseases that render a pilot unfit for flying. According to the International Convention of Air Navigation: 'The candidate must not suffer from any wound, injury or operation, not possess any abnormality congenital or otherwise which will interfere with the safe and efficient handling of aircraft. . . . He must not suffer from any disease or disability which renders him liable suddenly to become incompetent in the management of aircraft. He must possess heart, lungs, kidneys and nervous system capable of standing the effects of altitudes and of prolonged flight.'

(3)—Special Physiological Tests

Unsuitability and unfitness for flying

The following tests show (*a*) unfitness for flying at high altitudes or aerobatics, and the probability of an early onset of fatigue due to any cause, physical or mental, also (*b*) unsuitability for flying involving the stress of war or other severe strain, such as fog, darkness, engine failure over unsuitable country (mountains, towns, sea or desert), and collisions.

There is a difference between 'unsuitability for flying' (implying a tendency to break down early from stress) and 'unfitness', which may mean a liability to faint and lose control of the aircraft.

The tests have been adopted as Standard Tests by the Royal Air Force as adjuncts to the clinical examination, in order to enable the examiner to assess 'efficiency' for flying. A list of the apparatus necessary will be found on page 249.

The responsibility of the medical examiner is twofold: (1) to save life by preventing accidents due to physical unfitness, and (2) to prevent financial loss to the State or individual by certifying as fit a person who is likely to break down at an early stage of his flying career. He would regard the risk as being specially serious if the response to two or more tests were unsatisfactory—for instance, if there were a rapid pulse combined with marked tremors of the fingers or an abnormal blood-pressure.

Physical efficiency tests

'Efficiency' depends on stability of the nervous control of the vital functions of the body, and the so-called 'Efficiency Tests' have been found by experience to eliminate those who tend to break down at an early stage in a flying career.

Pulse-rate

The pulse-rate at rest and after exercise. The fittest pilots have a slow pulse-rate, usually about 60–65 per minute; on standing up, it increases slightly, about 12–15 beats, and after standing on a chair five times in 15 seconds, there is a further slight increase depending on the fitness of the pilot, followed by a return to the previous standing rate in about 20 seconds, e.g. sitting pulse = 60; standing pulse = 70; after exercise = 84; return to normal in 20 seconds.

An example of a more usual response would be: sitting pulse = 72; standing pulse = 84 (96 for the first 10–15 seconds); after exercise = 108.

Unsuitability for a flying career would be shown by a well-marked response to standing up. This is an indication of poor vasomotor tone, especially in the splanchnic area, so that the blood passing up from the inferior vena cava diminishes in amount and as a result the heart beats more rapidly in order to maintain the circulatory flow. Poor vasomotor tone is also associated with poor muscular tone. The experiment of holding up a hutch rabbit by its ears until it faints from a pooling of blood in the abdomen (which takes much longer to occur in the wild rabbit) shows the effect of gravity in causing anaemia of the brain from poor physical tone. An example of an unsuitable pulse response would be: sitting pulse = 72; standing = 108 (115–120 during the first 15 seconds).

Unsuitability for flying would also be shown by a large increase in the pulse-rate after moderate exercise; e.g. standing pulse = 84; after exercise = 120 with a long delay before returning to the 84 rate.

Unfitness for flying would be shown by a definitely rapid pulse (sitting rate 100 or over).

Blood-pressure

Measurement of the systolic and diastolic blood-pressures. Unsuitability for flying is shown by: abnormally high systolic and diastolic pressures, e.g. 160/100 (age: 20–30), or by a high systolic with a large pulse pressure, e.g. 150/70.

Unfitness for flying is shown by an abnormally low diastolic, e.g.

50–60, or a very low systolic pressure of the Addison's disease type, e.g. 90–95.

Breath-holding

Breath-holding test. A fit pilot can hold his breath for over 70 seconds: breath-holding for less than 50 seconds indicates unsuitability for flying.

Expiratory force

Measurement of expiratory force. Using the U-tube manometer, the fit pilot should blow the mercury to a height of 110 mm. Failure to do this in three attempts shows unsuitability.

Reflexes

The tendon-reflexes which should be tested are the knee, supinator and triceps jerks. Absent or exaggerated reflexes indicate an abnormal condition.

Tremors

Tremors of fingers and eyelids. Unsuitability for flying is shown by marked coarse tremors or twitching of the muscles.

Self-balancing

Self-balancing test. A fit pilot should be able to stand on one leg with the eyes closed for 15 seconds.

Balancing rod

The balancing-rod test. A small metal rod 6″ × ¼″ with a foot-piece about one inch in diameter is placed upright on a piece of wood 12″ × 4″. The test consists of lifting the board at arm's length from a table to the level of the shoulder without upsetting the rod. This is a useful test when the pilot has a marked tremor of the hands.

Endurance test

The 'endurance' test. (40 mm. mercury U-tube test.) With the nose clipped, the candidate is directed to empty the lungs completely, inhale fully, blow the mercury to a height of 40 mm. and maintain it there without breathing as long as possible, the pulse being counted in periods of five seconds throughout the performance of the test. The average duration of a large number of cases tested lies between 50 and 60 seconds. A duration of less than 40 seconds is unsatisfactory. In a good subject, the pulse-rate may remain almost steady or may rise gradually to 96, according to the time the breath is held. The pulse may rise almost at once from 72 to 84 or 96, and remain there. A large rise in rate, e.g. from 72 to 132 or 144, is unsatisfactory.

The test should be recorded thus: first, the number of seconds during which the mercury column is sustained, then the normal sitting rate per five seconds taken before beginning the test, and then the number of pulsations in each five-second period, the time taken to blow the mercury to 40 mm. being ignored. The normal sitting rate should be separated by a stroke from the rates during the test, e.g. 50 seconds 6/6677789888.

This test affords information as to the adequacy of the subject's respiratory intake, of the stability of the nervous centres controlling respiration and circulation, and of his power of endurance. Both respiratory and circulatory efficiency, as well as stability of control, are indicated by ability to maintain a relatively steady pulse-rate for approximately 50–60 seconds. On the other hand, a large rise in pulse-rate, e.g. from 72 to 132 or 144, is unsatisfactory, and is held to be indicative of cardio-vascular instability.

In cases of marked physical inefficiency a characteristic response is that the pulse-rate rises rapidly, e.g. to 132–144, during the second or third

Table showing requisite Vital Capacity according to Standing Height and Weight for Young Male Adults (Age 18–30).

STANDING HEIGHT	WEIGHT	VITAL CAPACITY
cm.	Kilos.	c.c.
159·90	39	3577
160·64	40	3619
161·37	41	3661
162·10	42	3703
162·84	43	3745
163·57	44	3787
164·30	45	3829
165·03	46	3871
165·77	47	3913
166·50	48	3955
167·23	49	3997
167·97	50	4039
168·70	51	4081
169·43	52	4123
170·16	53	4165
170·90	54	4207
171·63	55	4249
172·36	56	4291
173·10	57	4333
173·82	58	4375
174·56	59	4417
175·29	60	4459
176·03	61	4501
176·76	62	4543
177·49	63	4585
178·22	64	4627
178·96	65	4669
179·69	66	4711
180·43	67	4753
181·16	68	4795
181·89	69	4837
182·62	70	4879
183·35	71	4921
184·09	72	4963
184·82	73	5005
185·55	74	5047
186·29	75	5089
187·02	76	5131
187·75	77	5173
188·48	78	5215
189·21	79	5275
189·94	80	5299
190·67	81	5340

FIG. 40

period of five seconds and then falls even to below normal. Such instability is an adverse factor in air work and shows unsuitability for flying.

Vital capacity of lungs

Measurement of vital capacity of the lungs. This is measured with a spirometer and compared with the figures given on page 244. A poor vital capacity shows unsuitability for flying at high altitude.

3.–EXAMINATION OF THE SPECIAL SENSES

The eye

The pilot's vision is examined from the following points of view:

Visual acuity

Good visual acuity or form sense is necessary in order to fly level, by keeping the nose of the machine on the horizon and the wing-tips in correct position. The instruments must be read clearly and objects on the ground must be sharply defined in order to estimate their distance by their size.

Test-types

The examination should be conducted with well-illuminated standard test-types at a distance of 20 feet. The candidate must read the test-types without hesitation. The standard of visual acuity without correcting glasses for service in the Royal Air Force is: Distant vision each eye, V. = 6/6. The eye specialist, however, may at his discretion recommend acceptance when the visual acuity is equal to 6/9 (for Short Service Commissions 6/12) in each eye, provided that such vision can be corrected by glasses to 6/6 in each eye.

For private flying ('A' Licence), and for navigators ('B' Licence), a certain allowance is made and correcting glasses are allowed to be worn, provided a degree of visual acuity can be attained, with or without glasses, equal to at least 80 per cent of the normal visual acuity for each eye taken separately, or 90 per cent for one eye and 70 per cent for the other.

Hypermetropia

No candidate, generally speaking, will be passed who reveals a manifest hypermetropia (that is, hypermetropia revealed without the use of a mydriatic) of 2·00 D or over.

Peripheral vision

Peripheral vision must be normal both for judgement of speed on landing and also for seeing other aeroplanes moving in the vicinity, as in formation flying.

Colour vision

Normal colour vision is required for reading signals and for landing at night. The most efficient test for colour vision is Ishihara's plates published by Kanehara of Tokyo. These tests are so sensitive that they can be relied on to pick out all types of colour blindness. See the article on COLOUR BLINDNESS.

Judgement of distance

In order to judge distance on landing, aeroplane pilots rely mainly on binocular stereoscopic vision (by stereoscopic vision we mean perception of depth). Maintenance of this faculty requires not only a good balance of the eye muscles (orthophoria) but also a mental faculty known as the 'fusion sense'. The convergence-power of the eye muscles must also be good as well as the ability to concentrate. Binocular stereoscopic vision is one of the more recent acquirements of primates, and so is early affected by fatigue, toxaemia, cerebral concussion, alcohol

Stereoscopic vision

and disease. Therefore it is not surprising that when the first investigations were made by Group Captain E. C. Clements into the causes of bad landings of pupils, he found that this faculty was defective in those who made errors of judgement of distance on landing.

In testing vision we first of all test the acuity of each eye separately and then the 'single binocular vision' faculty—i.e. the power to fuse the vision of two eyes so as to see one object in perspective.

Convergence tests

To test the convergence-power of the eyes, hold a pencil in front of the candidate at about one foot from his eyes, with the point on a level with the root of his nose. Tell him to fix the point, then steadily move it towards his eyes watching what happens to them as they converge. The following may occur:

Both eyes may converge, fixing the point of the pencil until it gets within an inch or two from the root of the nose, indicating good convergence power.

One eye may continue to converge until the pencil is an inch or two from the root of the nose, but the other may cease to follow and turn outwards at any distance.

Both eyes may fail to converge, and the candidate may look into the distance stating that he sees double, as soon as the pencil begins to move towards his nose; this may occur anywhere inside 10 inches.

In the second and third cases, convergence is defective. Convergence-power is judged by the following standards: 2 inches or under = very good convergence; 2 to 3 inches = good; 3 to 4 inches = fair; over 4 inches = poor.

Tests for defective eye muscles

Tests for defective eye muscles must also be performed. In order to see an object singly with two eyes and judge distance and depth accurately, the eyes must work harmoniously together, as well as converge. When one eye looks at a pencil the other eye, even when covered, should follow and look towards it. The following cover test will reveal lack of ocular muscle-balance which in practice we often find associated with errors of judgement in landing an aeroplane.

Cover test for muscular defect

Direct the candidate to look at the pencil (as in the convergence test) at about one foot from the nose, and with the other hand cover one eye with a card. Move the pencil from side to side and finally bring it back to the centre, directing the candidate to watch the moving pencil. Then uncover the eye and notice whether it moves on uncovering, and if so, whether it moves quickly or if there is a pause before it looks at the pencil.

When the eyes are badly balanced and co-ordination is poor, the covered eye will be seen to be directed outwards, not looking at the pencil, and will remain gazing into distance, or will, after a delay, move slowly inwards and look at the pencil. (A latent or concealed squint.)

Good ocular balance is shown by the covered eye being found to be accurately fixed on the pencil, or, as soon as the card is removed, to turn immediately to the pencil.

Two other tests are used to confirm the two described, viz.: the red-green phorometer, and Bishop Harman's diaphragm test. These are described in the official Air Ministry publication *The Medical Examination for Fitness for Flying* and require special apparatus.

Visual standards

The standard of vision was reduced during the War, owing to the needs of the service. Bowdler has analysed the records of the pilots of the R.A.F. and reported that small visual defects were present in 20 per cent of successful pilots, but only 2 per cent had a visual acuity as low as 6/12, 6/18. It was eventually found that the percentage of accidents and of failures to qualify during training was definitely higher when the standard of vision was lower than 6/9 in each eye.

The following figures were given by the R.A.F. consultant in ophthalmology:

VISUAL STANDARD (SNELLEN'S TEST-TYPES)	PERCENTAGE OF ACCIDENTS AND FAILURES DURING FLYING TRAINING
6/6	5
6/9	8–10
6/12	15–20
6/24	40

Hypermetropia over 2 dioptres was a disqualification and it was found later that spasm of accommodation occurred when hypermetropes were exposed to sun glare in the East. There was very little known about Night Flying Vision, but Group Captain E. C. Clements reported that pilots who could not see well at night usually had abnormal colour sense.

Visual judgement of distance

Reference has already been made to the high percentage of accidents in pupils learning to fly, due to errors of judgement in landing. In 1916 a number of pupils who were bad landers were sent to Clements, then ophthalmic specialist at the 4th Northern General Hospital, Lincoln, from aerodromes in the vicinity. Clements had noted that defects in ocular muscle-balance were associated with motor accidents, especially when the driver was fatigued. Further, that individuals engaged in certain occupations involving close eye-work, such as clerks, engineers, draughtsmen and architects, suffered from a similar condition. He examined the pilots concerned, and found a resemblance to the symptoms he had previously noticed, and devised a series of simple tests to estimate what he now calls 'visual judgement of distance'. Not only was Clements successful in discovering the individuals with defective visual judgement of distance, who were prone to make bad landings, but he was able to re-educate and train the binocular machinery so that the judgement became normal and the pupils were able to land correctly.

It has been estimated that 85 per cent of bad landers who were trained by him became safe and reliable pilots. The failures had other defects including nervous disorders, fear of flying, mental sluggishness or poor manipulative ability.

The ear

A pilot should be able to hear perfectly, and if he can hear a whisper at 20 feet he can be considered normal. For private flying ('A' Licence) he must be able to hear the whispered voice at one metre. Failure to detect a slight variation in the note of the engine when climbing may result in a 'stall' and subsequent crash.

Pressure in middle ear

When there are rapid changes of atmospheric pressure, as when descending rapidly from a high altitude, pilots have ruptured the tympanic membrane or become giddy. Normally, air passes through the Eustachian tubes on swallowing, and the pressure inside the ear adjusts itself. If one or both Eustachian tubes are blocked as the result of a cold in the head, sudden variations in altitude will produce an abnormal condition of tension in the middle ear. This, acting on the vestibular apparatus, produces intense pain and giddiness.

Valsalva's test

Most experienced pilots know the good effect of swallowing during a rapid descent and some chew gum to help this. Valsalva's test is useful in this connexion: The subject holds his nose tightly and blows down hard through the nose until he hears a click in the ears as the air is forced up the Eustachian tubes. The examiner may confirm this by putting one of the tubes from his stethoscope in the subject's ear and listening to the click. Finally, acute or chronic disease of the middle ear is a cause for rejection.

Disease of ear

The nose and throat

Symptoms arising from obstruction in the nose and throat indicate unfitness for flying at high altitudes. Minor defects, without symptoms and with free air entry, may be disregarded.

The teeth

Pyorrhoea alveolaris (chronic suppurative periodontitis). Septic absorption from the teeth and periodontal membranes may cause unfitness in two ways, (*a*) by causing arterial hypertension, and (*b*) by affecting the balance of the eye muscles and so causing errors of judgement of distance on landing.

Value of standard tests

In Bauer's *Aviation Medicine*, the official text-book of the United States Air Force, it is stated that 'during the first year of the War, out of every hundred aviators killed in the British Air Force, two met death at the hands of the enemy, eight because of defective planes or motors, and ninety were killed due to their own individual deficiencies. Of these ninety, sixty were found to have been due to physical defects. As the result of a standard medical examination, casualties due to physical defects were reduced from sixty to twenty and eventually it was found that a still further reduction had been made from twenty to twelve.'

The evidence that the medical standard of fitness is correlated with flying efficiency is as follows: 177 efficient pilots were selected by the executive branch of the R.A.F. for permanent commissions in 1917 and 1918, and all of them passed the standard tests; 112 pilots suffering from fainting and giddiness at altitudes were examined in 1917, and of these only one passed and 111 were below the standard; 92 pilots suffering from nervous symptoms and 'temperamental unfitness' were examined in 1917, and only 10 passed the tests and 82 failed.

4.–SPECIAL TESTS FOR AEROBATICS

Before stunting on high-speed aircraft it is essential that a pilot should undergo the complete medical test for flying as carried out at the Central Medical Establishment of the Royal Air Force, but a few words on the effects of centrifugal force as in looping or rapid turns may be of interest.

In looping, the pilot has at first a sensation of being pressed down into his seat. This is due to centrifugal force, which also tends to cause cerebral anaemia. Normally the body adjusts itself to meet the strain. If, however, this force reaches 4½ times gravity, the pilot 'blacks-out' owing to lack of blood in the brain. There is no cause for anxiety when looping on a machine like the Bristol Fighter, for the force only rises to about 3 g, but blacking-out has occurred when cornering on machines flown in the Schneider trophy contests.

Pilots can in some cases prevent 'blacking-out', even at this speed, if they are in hard muscular condition with really firm abdominal muscles, if they take a breath and hold it, at the same time contracting the abdominal muscles. This raises the intra-abdominal pressure and tends to oppose the forces acting from without.

Fitness for aerobatics depends then on normal circulatory and muscular tone combined with good abdominal muscles.

Spinning

Rapid rotary movements such as spinning cause certain persons to faint or become giddy. These persons usually give a history of discomfort or of sickness on swings, trains and roundabouts. They should be tested by being rotated on a chair ten times in twenty seconds with the head bent forward into the axis of rotation. The individual who cannot control the impulses from his semicircular canals either faints or sways right over to one side and is unable to sit up for several seconds. Experience has shown that more elaborate tests for the vestibular mechanism are unnecessary if the subject can pass the rotary-chair test successfully.

5.–LIST OF APPARATUS REQUIRED

Stop-watch. Simple U-tube manometer with a mouth-piece and rubber tube. (There should be 6″ of mercury in the U-tube, which is graded in mm. and is similar to an ordinary sphygmomanometer except that the bore is larger.) Nose clip. A spirometer recording in litres and tenths of litres. Sphygmomanometer. A balancing rod 5″ high, and ¼″ diameter, weighing 1⅙ oz., with a thin circular footplate of ⅞″ diameter, a board about 4″ wide, 12″ long and approximately ¼″ thick, weighing 4 oz. (This can be obtained from Messrs. Allen & Hanburys, Ltd.)

For the eye-test, an ordinary set of Snellen's test-types is required, also a red-green phorometer with spectacles of red and green glass, a Bishop

Harman's diaphragm instrument, and a small foot-rule for measuring the near point of convergence. Three tuning forks are required for testing auditory acuity—64, 256, and 4,096 vibrations per second, and a rotating chair.

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Bauer, L. H.	*Aviation Medicine*, London, 1926.
MacMillan, N.	*The Art of Flying*, London, 1928.

AYERZA'S DISEASE

See ASCITES, p. 154; *and* ERYTHRAEMIA

BACILLURIA

See COLIFORM BACILLUS INFECTIONS; *and* URINE EXAMINATION

BACKACHE AND LUMBAGO

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Reference may also be made to the following titles:

ACTINOTHERAPY
ARTHRITIS
BONE DISEASES
DYSMENORRHOEA
ELECTRODIAGNOSIS
ELECTROTHERAPY
FIBROSITIS
HEAT, RADIANT
MASSAGE
SCIATICA

1.–DEFINITION

117.] Although the subject of backache in its strict sense includes the consideration of pain in any portion of the back, for the present purpose it will in the first instance be sufficient to confine consideration of the subject to the area of the back commonly affected in 'lumbago'. Taken literally, 'lumbago' means pain in the lumbar region of the back. To say a patient is suffering from 'lumbago' is therefore merely to express the examiner's opinion that the pain is physical, not psychological, in origin, but does not throw any light on the diagnosis.

2.–DIAGNOSIS

The causes of low backache fall under two main headings: (1) Extrinsic and (2) Intrinsic.

(1)—Extrinsic Causes

Extrinsic causes are numerous, for the pain may be referred from many sources. Every endeavour should be made in taking the history, and during a preliminary examination, to exclude them as far as possible. Otherwise, after an extensive examination which may well be arduous for both the medical attendant and patient the cause is still to seek, but may become obvious later when the mental focus of the examiner has changed.

Referred pain

Some forms of low backache are not in any way due to changes in the spinal column, the muscles, ligaments or other structures in this region. Pain may be referred from more deep-seated structures; for instance, in one form of backache the patient complains that the site of pain is directly over the back of the sacrum, but nothing can be felt on pressure, cutaneous sensation is unaltered, and nothing abnormal can be seen; yet pain may be definite and severe. Suspicion at once falls on the lower part of the bowel, and if haemorrhoids are the source of irritation the only effective treatment is their removal. An ischio-rectal abscess and carcinoma of the prostate or rectum may produce similar symptoms.

From gynaecological conditions

Contrary, however, to the usual teaching, prolapse of the uterus, when present, is not necessarily a cause of pain in this situation, or indeed of low backache in general. This must not be taken to mean that appropriate gynaecological treatment for prolapse is useless as regards the treatment of low backache. It is merely a warning to the diagnostician that there may be other conditions present causing the backache, and, if these are not recognized and treated, the result of operation may be unsatisfactory from the point of view of the backache. An impacted fibromyoma or pregnant uterus may be included amongst the causes of low backache, but although treatment of prolapse immensely relieves symptoms other than backache, as a rule any sort of gynaecological treatment for the pelvic floor, except when prolapse is extreme, may be disappointing as a cure for low backache.

There are, however, several other gynaecological conditions in which low backache may be a prominent symptom. Carcinoma of the uterus, for example, is often accompanied by an indefinite aching in the lower part of the back, and pain of varying degree may accompany the normal process of menstruation, although it is liable to be far more pronounced if dysmenorrhoea is present. Both can often be relieved by suitable gynaecological treatment.

Backache during pregnancy

During pregnancy also backache is relatively a common symptom, but now the pain is usually postural, and only indirectly due to the increase in size and weight of the pregnant uterus. After delivery backache as a prominent symptom may be due to any of several causes. The exact diagnosis depends on the result of examination. Post-maternity backache is not a diagnosis, it is merely a symptom of some definite lesion that has arisen in connexion with delivery or conditions that arise as a direct sequel to it. For example, intrapelvic sepsis may be the cause of acute backache and particularly if posterior parametritis (utero-sacral cellulitis) is present secondary to cervical infection.

Backache following operations

After many operations, not only of a gynaecological nature, backache, which may be very severe, is a common complaint. The cause is often an indirect sequel to the operation, and differential diagnosis can be made only as the result of full examination. A common cause, however, is the complete muscular relaxation, which allows an undue flattening of the lumbar curve. Many an intractable case of backache might be avoided by the simple precaution of placing an air-cushion under the lumbar spine in order to support it during all abdominal operations.

Neurological patients not infrequently seek advice in the first instance for pain in the lower part of the back. In fibroma of the cauda equina backache may be the most prominent, perhaps even the only, symptom at first, and patients with disseminated sclerosis seem, for no very obvious reason, to complain of low backache before any other symptom is recognized.

Other causes of referred pain

And so the list can be continued almost indefinitely. There is the backache associated with rise in temperature, particularly in smallpox, tonsillitis and influenza; the chronic ache with pyelitis, renal calculus or nephritis. Much the same, however, may be said of the movable kidney as has been said of prolapse. Because a kidney can be felt to be unduly mobile, it does not follow that the backache of which the patient complains must necessarily be associated with it directly or indirectly. Thus nephropexy or other operation may fail entirely to bring relief to this symptom. Of other intra-abdominal conditions that are directly associated with backache, cancer of the pancreas and duodenal ulcer eroding it, cancer of the stomach, and abdominal aneurysm all deserve notice. Even an overloaded bowel may suffice to cause referred pain in the back, and an aperient may suffice to cure it.

It is therefore plain, from these few examples amongst many, that if a patient is suffering from lumbago of any considerable duration, a most thorough search must be made so as to exclude the possibility of causes that have nothing whatever to do directly with the back.

(2)—Intrinsic Causes

(*a*) *Bone Disease*

Metastases

Metastases from a primary growth, perhaps at a considerable distance are not infrequent and may arise in any part of the skeleton, but most often in the bones of the back; this applies more especially to the lower part of the back, in which the ilia are here included, than to the upper part. Diagnosis rests on the result of X-ray examination.

Paget's osteitis deformans and osteoporosis

Two bone conditions must be specially mentioned, as attention is frequently drawn to them in the first instance by pain in the lower part of the back. These conditions, which are quite distinct from one another, are Paget's osteitis deformans and general osteoporosis. The latter condition is characterized by a deficiency of mineral salts within the bones, which leaves them with an 'egg shell' consistency. When the spinal column is affected, minute strains are liable to cause crush-fractures of the bodies—usually near the anterior aspects. In the lumbar region this leads to a flattening of the normal curve; in the thoracic region to an accentuation of it. The pain is continuous, but liable to acute exacerbations.

Treatment

Fortunately there is now some reason for supposing that both conditions can be arrested, or at least held in abeyance, by six months' continuous and daily treatment by general ultra-violet light combined with the administration of a standardized concentrate of vitamin D (e.g. ostelin). So far the number of cases treated in this manner has been too small to justify the categorical statement that the treatment is 'specific', but the results to date have been sufficiently encouraging to justify the continued prescription of the treatment. The technique to be followed, if the treatment is to be a success, is very definite. At first the exposures should not last more than one minute a day, front and back, and should be increased by not more than one minute a day until a maximum of ten minutes a day, front and back, is reached. Any trace of desquamation shows that the advance of the treatment is too rapid. When the maximum time of exposure has been reached, treatment should be continued uninterruptedly to the prescribed limit. Roughly speaking, it may be said that the disease is checked during the first two months, remains practically stationary for the second two months, and improves quite definitely during the third period of two months. It is advisable to continue prophylactic doses for a month at a time, three times a year. In this way there is reason to hope that these conditions, even in an advanced stage, can be arrested, though naturally nothing can be done to remedy any deformity which may have occurred before treatment began.

Diseases involving other bones are liable to affect the bones in the lower part of the back, but generally speaking these are too rare to merit special consideration.

(*b*) *Joint Disease*

Tuberculosis

Tuberculosis, particularly of the sacro-iliac joint, always presents as its first symptom pain in the lower back, and it is often present long before any definite evidence can be secured even as the result of X-ray examination. Treatment of a nature similar to that needed for joint tuberculosis elsewhere will be required.

Arthritis

Arthritis of the joints of the lower part of the back may be part of a general disease of the joints, or it may be a purely localized condition. Evidence of mild degrees of arthritis is constantly found on X-ray examination of patients who, it may be, have never complained of pain in the back at all. This at least is the story, although as a rule careful examination will reveal that there has been, at some time or another, a certain amount of pain; but it may have been too insignificant to have interfered with the normal activities of the patient. Still the fact remains that an inflammatory condition has at some time been present, and that the joints are not as perfect in their function as they would have been had the disease not existed.

Inflammation

Again many patients present themselves for examination on account of comparatively recent pain in the lower back, and X-ray examination reveals changes which must have been present for a much longer period than the symptoms. The condition coincides exactly with that which is so often seen in minor injuries to the shoulder-joint, when the limitation and pain on movement increase so slowly, that weeks, or it may be months, elapse between the onset of the inflammatory condition and the date of seeking advice.

The joints in the lower back most commonly affected in this way are those at the lumbo-sacral junction and between the 4th and 5th lumbar vertebrae. In spite of changes visible on X-ray examination, the prognosis of these cases is very favourable if manipulative treatment is given, and particularly so if subsequent mobility of the joints can be maintained voluntarily. If, however, there is any reason to suppose that the joints are still in an active state of inflammation, no attempt at manipulation should be made until the source of infection has been discovered and, as far as possible, eradicated. While this is being done, every effort should be made to save the joints from minor injury by the use of support and by curtailing every activity (including motoring) which tends to aggravate the symptoms. Local treatment is palliative only, and not curative. Even advanced changes, as shown radiologically, must not contra-indicate manipulative treatment when the inflammatory condition has become quiescent.

Indications of active inflammation

Fortunately, in trying to decide whether the condition is one of active inflammation or only the late result of a past inflammation now quiescent, there is one fairly certain test. If a patient finds that on waking after a night's rest the movement of a joint is stiff and painful, but that these symptoms gradually wear off with activity and return again as the result of rest, the chances are that a low-grade, but active inflammation is still present. If, on the other hand, rest brings relief, whereas exercise increases pain in direct proportion to the amount of exertion, there is reason to believe that the symptoms are the effects of past inflammation, and that manipulation will bring relief. Naturally, if a joint is in a state of acute inflammation, movement of any sort will cause acute pain, but difficulty in diagnosis is not likely to arise during the acute stages. It is only when the acuteness of the symptoms has subsided, and a decision must be made whether to manipulate or to wait, that this guide is of service.

Finally, it should be noted that, although naturally the prognosis is not quite so favourable, changes in the vertebrae—i.e. lipping of the edges of the bodies—are of far less significance, from the point of view of manipulative treatment, than are changes in the joints between the articular processes.

Spondylitis of adolescence

One form of arthritis of the spine calls for special mention. Many consider that spondylitis of adolescence starts invariably with disease of the sacro-iliac joints and spreads upwards. The most probable explanation of the condition is prolonged strain or jarring of the joints of the spine when an active focus of infection is present elsewhere, and particularly if the infection is closed. Pain, although present, is not as a rule the prominent symptom that would be expected, and the patient usually seeks advice for increasing stiffness rather than for pain. In the early stages there is a curious immobility which is not seen in other conditions, and which precedes any definite X-ray evidence of disease. As a rule patients do not come for examination until the condition is so far advanced that X-ray examination at once reveals the true nature of the condition. Deep X-ray therapy is the only treatment that seems to offer any hope of amelioration; but even in advanced cases, so long as ossification of the ligaments has not taken place, the amelioration may amount to complete cure. All other treatment is futile and not even palliative.

(c) *Traumatic Arthritis*

Mobility of sacro-iliac joint

Many cases of lumbago are entirely due to injuries of the joints in the lower part of the back. Up to comparatively recent times the sacro-iliac joint was regarded as perfectly stable and without movement except in the special circumstances of parturition; but it is now known that, however stable this joint may be in the vertical direction, there is a normal and free mobility between the ilium and the sacrum in a rotatory direction. This can easily be proved by measuring the distance between the posterior superior spines of the ilia in the sitting position, and comparing this measurement with a corresponding one taken in the prone position. In a normal, healthy individual, the two spines approximate to one another to the extent of, roughly speaking, half an inch when lying prone. It is a matter of indifference whether the ilia rotate backwards on the sacrum, or the sacrum rotates forwards on the two ilia. It may be regarded as certain that, although the range of movement may be small, there is free mobility in these joints.

Locking of the sacro-iliac joint

If unusual strain is laid upon the sacro-iliac joint so as to force it beyond the normal limit of movement, the two bones lock on one another. This may also occur in other joints and the strain may lead to dislocation or tearing of the ligaments; but in this joint, with its peculiar structure and immensely strong attachments, locking is the inevitable result of severe rotation strain. The result is an acute condition, corresponding very closely with the locking so common in the knee-joint. In the sacro-iliac joint there is, of course, no interarticular cartilage, but the effect is similar; and just as the locking of the knee-joint may sometimes be very transitory and present great difficulties in other cases when any attempt at manipulation is made, so too the same may be said of the sacro-iliac joint. Indeed, just as the locking of the knee-joint, however transitory, will cause traumatic arthritis subsequently, so the most transitory locking of the sacro-iliac joint must lead to a similar condition. If the locking persists, in either case, far more serious trouble develops, and in the case of the sacro-iliac joint the disability may be prolonged and severe, and be excruciatingly painful. It must be understood that minor injuries may lead to most acute effects, and such common events as slipping while stepping out of the bath, or sneezing while the weight of the body is resting on one ischial tuberosity, are quite sufficient to produce the most lamentable results. Moreover, pain is not always confined to the joint in question, but frequently radiates right down the leg, giving rise to a pseudo-sciatica. The history is usually quite definite, namely, that a sudden sensation of pain was felt during some movement, usually of an unguarded character. The severity of the pain varies according to that of the lesion. It may be that only a slight twinge is felt, which passes off entirely in the course of a few days; or the patient may suffer so severely from shock as to give the appearance of having broken his back. The remedy is to restore mobility at the earliest possible moment, and it is unfortunate that this cause of pain in the lower part of the back is not universally recognized. If the joint is left in the locked condition, strain on the ligaments will be severe, they will slowly stretch, and thus make recurrence far more probable.

If the symptoms are too acute to allow of an adequate examination, the only thing to do is to administer an anaesthetic at the earliest possible moment and restore any mobility that may be lacking. In less acute cases the examination necessary to decide whether one of the joints is at fault, and, if so, which one, may be long and highly technical; and for an accurate diagnosis it is essential to rotate the ilium on the sacrum in both directions in every possible position.

(i) The Sacro-Iliac Joint

The following points should be noted:

Sitting

When sitting the patient tends to support the weight of the body on the ischial tuberosity of the uninjured side, and there is a definite concavity in the lower lumbar spine towards the injured side. Stooping is limited and painful, and the patient tends to lean forward so as to carry the trunk away from the injured side. Rotation of the trunk in the sitting position causes pain in both directions if active inflammation is still present, but only in one direction if the symptoms caused by the locking of the joint are not very severe.

Standing

When standing the patient prefers to carry the weight on the leg of the uninjured side. Stooping is far more limited than in the sitting position.

Lying

Examination of the abdomen with the patient lying down will sometimes reveal the true nature of the condition. If a line is drawn from the umbilicus to the anterior superior spine of the ilium, there are four points at which tenderness may be elicited. MacBurney's appendicitis point is situated at approximately the middle point of this line, and Baer's sacro-iliac point is situated two inches along its length, away from the umbilicus. In an ordinary comparatively thin patient these two points are not more than half to three-quarters of an inch apart. At the outer end of the line it is possible to palpate the iliacus muscle, and if this is infiltrated with sensitive deposits, one of the most tender spots will be in this situation. A little further out, immediately over and above the anterior superior spine, the external cutaneous nerve pierces the deep fascia and, if for any reason the inflammatory condition has interfered with the free mobility of the nerve through this opening, traumatic neuritis is liable to follow. There should be little difficulty in recognizing this condition, as there is always a certain degree of disturbance of sensation over the distribution of the nerve, and pain is confined to this area (see Fig. 41 and article on NEURITIS).

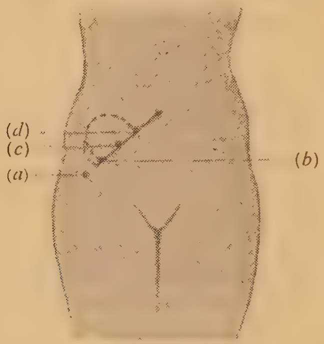


FIG. 41.—To show the close relationship between Baer's sacro-iliac point and MacBurney's appendicitis point. (*a*) anterior superior spine, just above which the external cutaneous nerve pierces the deep fascia; (*b*) common situation for fibrositic deposits in the iliacus; (*c*) MacBurney's point; (*d*) Baer's sacro-iliac point.

(This, and the following illustrations, are modified from the Author's *Backache*.)

Sciatic scoliosis

Sensitive deposits in the iliacus muscle are liable to lead to that peculiar condition which is known as 'sciatic scoliosis'. Diagnosis depends in the first place upon the finding of the sensitive deposits in the iliacus muscle, not only internal to the anterior superior spine, but also in the muscle where it passes underneath Poupart's ligament. Diagnosis further depends on the presence of sensitive deposits elsewhere in the muscles, and successful treatment is conditional on the removal of the cause of the deposits, usually a hidden focus of infection. The deformity is due to flexion and adduction at the hip-joint owing to the spasm of the ilio-psoas. After the joints in the lower part of the back have been held in the strained position for any considerable time, it is not surprising if the joints become stiff and set, and although one element of cure frequently depends on restoration of mobility in these joints, this is only to be regarded as the treatment of the result of the inflammatory process, and should in no way be regarded as the primary treatment which is necessary for the cause. At best, the treatment of this condition is often long, and disappointing to all concerned. Sciatic scoliosis may also be due to insufficiency of the ilio-tibial band, or to a locking of the joints at the lumbo-sacral junction. Both will be considered later (see p. 263).

Returning to the sacro-iliac joint, if tenderness is detected over Baer's point it may be found that it is increased by pressing the anterior superior spine of the ilium forwards and upwards, and lessened by pulling the back of the iliac crest forwards. When present, this sign is pathognomonic, but unfortunately it cannot always be demonstrated with sufficient accuracy to be of service.

Differentiation of sciatica from sacro-iliac strain

Some years ago it was taught that if elevation of the leg in the lying position with the knee straight caused pain radiating down the leg, the patient must be suffering from true sciatica. It is now known that this is not the case, as the same movement puts strain upon the hamstrings, and thus, by pulling on the ischial tuberosity, tends to rotate the ilium backwards on the sacrum. It is therefore necessary to distinguish between these two conditions. By checking the movement when the first twinge of pain is noticed, it will be found that if the foot is unsupported it will have dropped into a position of plantar-flexion. If now the foot is dorsiflexed, extra tension will be laid upon the terminal branches of the sciatic nerve, and if active inflammation is present in the sheath of the nerve, the pain will be increased. This movement does not cause extra strain on the ligaments of the sacro-iliac joint, provided that it is made carefully. Therefore, if the movement of dorsiflexion of the foot does not increase the symptoms, there is strong evidence that the sacro-iliac joint is at fault (see Fig. 42). Next, if the leg on the opposite side is raised, no pain will be noticed on the injured side until a wide range of movement has been performed, and then pain may be felt upon the injured side. This cannot be due to a true sciatica (even if this co-exists), as no extra tension can be placed upon the nerve as a result of this movement. The symptom is now reproduced by forward torsion-strain of the sacro-iliac joint on the injured side. As the leg is raised on the sound side with the knee straight, the pull of the hamstrings first of all rotates the ilium backwards on the sacrum, and, having reached the limit of normal movement, if the leg is carried still further, it may be noticed to carry the sacrum with it, and this involves movement of the sacrum on the ilium on the injured side.

If both legs are now raised together in a similar manner, pain will be felt at a point more or less midway between those at which pain was previously elicited during movement of the two legs separately. The explanation of this is that raising the sound leg with the injured one takes away, as it were, the anchor from the pelvis, and so the strain of the movement on the injured side is not felt until a wider range is covered. If, however, pain is elicited at an earlier point when both legs are raised together than it is when each is raised separately, it is clear that symptoms arise in the lower lumbar spine, and probably at the lumbo-sacral junction.

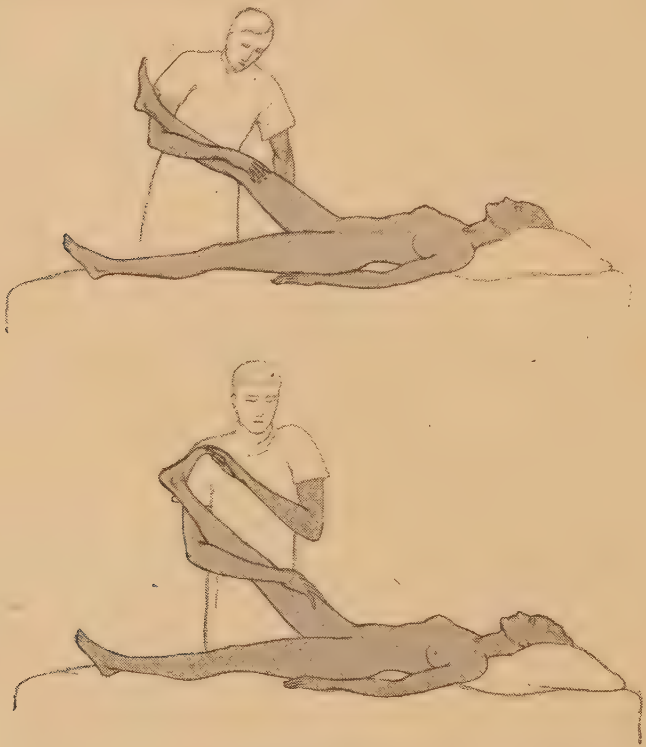


FIG. 42.—A method of differentiating between true sciatica and sacro-iliac strain

Side-lying

The patient is now placed on the sound side, and the knee of the painful side is bent to a right angle. By extending the hip, tension is exerted on the rectus femoris and Y-shaped ligament, tending to rotate the ilium forward at the sacro-iliac joint (see Fig. 43). If this movement, as well as rotation backwards, is painful, it follows that pain can be caused by movement in both directions, and in this event it is also known that the joint is unstable, and therefore that rest and support, rather than manipulation, are indicated. In the side-lying position it is also possible to exert a backward torsion-strain by pushing the ischial tuberosity forward, whilst pulling the anterior superior spine backwards. So, too, a direct forward torsion-strain can be placed upon the joint by rotating the trunk as far as it will go by pulling the shoulder backwards (see Fig. 44). By fixing this we are able to fix the whole trunk, and then direct pressure forwards over the crest of the ilium exerts a direct forward torsion-strain upon the sacro-iliac joint. The patient is next rolled on to the injured side and the same movements are performed on the sound leg. Any movement of the sound leg which causes pain to be felt on the injured side, is due to movement of the sacrum on the ilium. It is, however, necessary to emphasize that forward torsion-strain on the sound side, if carried far enough to move the sacrum, produces a movement which corresponds to a backward torsion-strain upon the injured side.

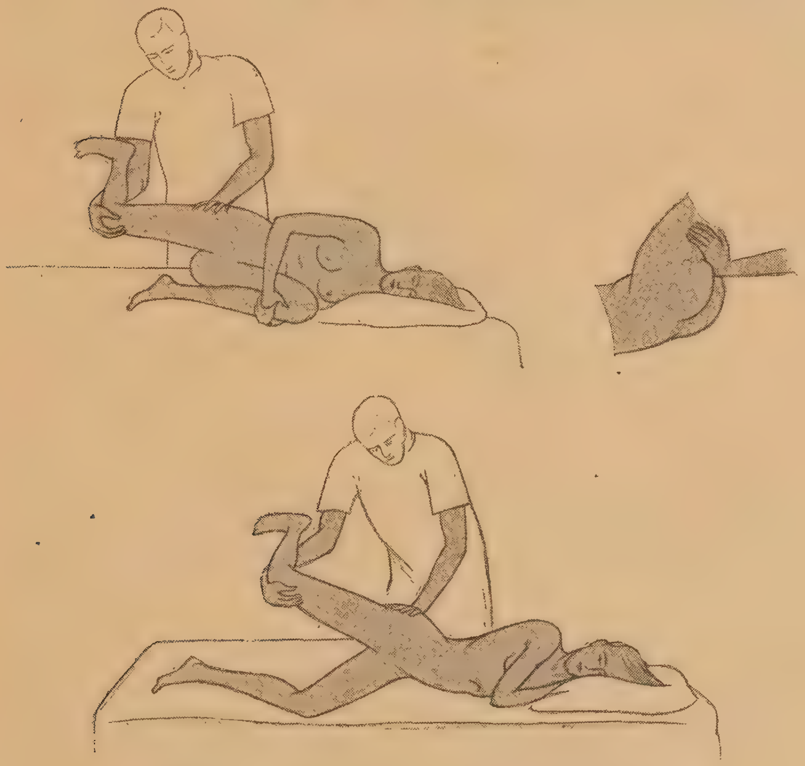


FIG. 43.—Forward torsion-strain on right sacro-iliac joint in side-lying position

Differentiation of sacro-iliac from lumbo-sacral lesions

During examination in the side-lying position it must be borne in mind that, if the lumbar spine is not fixed while extending the hip-joint backwards, the movement performed will be divided between the lumbar spine and the sacro-iliac joint. If, therefore, doubt arises as to which joint is at fault (i.e. the sacro-iliac or the lumbo-sacral) it is necessary to fix the pelvis by flexing the thigh on the side nearest the couch on to the chest, where it is held by the patient's hands. This anchors the lumbar spine, and one of two things may happen. (1) If the upper hip-joint is then hyperextended with the knee flexed to a right angle, and pain is caused, it is obvious that, as the lumbar spine cannot move, the symptoms must of necessity arise from the sacro-iliac joint. This may be confirmed by releasing the knee that is flexed on to the abdomen (while keeping the other hip-joint in hyperextension) when the lumbar spine at once begins to move, thereby releasing the strain on the sacro-iliac joint, and pain disappears. A wide range of painless movement is thus possible, but when the lumbar spine has moved to its full extent, the strain is again felt at the sacro-iliac joint and the pain returns. (2) If, on the other hand, while the side next the couch is flexed upon the abdomen, movement of the uppermost thigh backwards does not cause pain, it is known that the forward torsion-strain of the sacro-iliac joint is painless. If the flexed hip is then released, the movement is transmitted as before to the lumbar spine, and if this causes pain there is definite evidence that the symptoms arise from the lumbo-sacral junction, or, at least, from the lower lumbar spine.

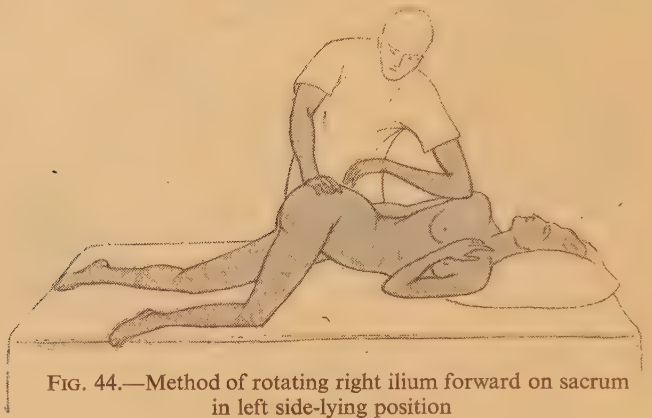


FIG. 44.—Method of rotating right ilium forward on sacrum in left side-lying position

Insufficiency of ilio-tibial band

One other point is of the utmost importance. When the uppermost of the two thighs is extended backwards with the knee bent, it should be possible to lower this knee on to the couch. In many cases of low backache, and particularly if a sciatic scoliosis is present, the knee may fail to drop and remains suspended, as it were, in midair. This is due to insufficiency of the ilio-tibial band. When present this can be a prolific cause of low backache and referred pain. The band is most taut when the thigh is in the mid-position, for in this position it is held on stretch by the great trochanter. When the hip is flexed the tightest part of the band passes in front of the trochanter; when it is extended it passes behind. Thus, in walking, as the tightened band passes over the great trochanter, a kind of see-saw strain is laid on the sacro-iliac joint.

Moreover, the lack of adduction of the hip cramps the free movement of the pelvis, and this may lay a severe strain on the lumbo-sacral junction. Indeed the strain may be felt even above this level.

Prone position

The patient is examined next in the forward-lying or prone position, and by placing a hand over the ischial tuberosity the pelvis can be anchored on the couch. The knee of each leg in turn is then bent to a right angle, as in the side-lying position, and the thigh is raised from the couch. This exerts a forward torsion-strain upon the sacro-iliac joint on the side that is moved, and a backward torsion-strain on the opposite side. In this position raising both thighs together causes immediate movement at the lumbo-sacral junction, and, as the legs are raised higher, the other joints of the lumbar spine begin to move in turn, starting from below upwards. This movement, however, cannot be performed without laying a considerable forward torsion-strain on both sacro-iliac joints, owing to the weight involved in the lifting. If the ilio-tibial band is unduly taut, it will be impossible to raise the thigh on the affected side directly upwards so freely as on the sound side. With the thigh abducted, the movement becomes quite free owing to relaxation of the band.

Raising the trunk from the couch, and exerting counter-pressure from above downwards, will elicit pain on movement in the upper lumbar spine.

During examination of the sacro-iliac joint it may be taken for granted that if pain occurs only when one ilium is rotated in one direction, manipulation is indicated. But, as already stated, if pain is elicited when the ilium is rotated in either direction, an inflammatory condition is present, traumatic or otherwise, and this condition calls for rest and support.

(ii) The Lumbo-Sacral Joints

Joints in this region other than the sacro-iliac joint may suffer from injury, and the lumbo-sacral junction is particularly vulnerable. Much has already been said about the differential diagnosis of trauma of the sacro-iliac joint and of the lumbo-sacral joints. One other point needs consideration. If the patient is placed in the lying position, and the hips are flexed till the thighs are vertical, with the knees bent over the examiner's forearm, the pelvis can be swung first to one side and then to the other (see Fig. 45). This acute side-bending movement of the pelvis on the trunk is most free at the lumbo-sacral junction. If, therefore, side-bending of the pelvis is more limited to one side than to the other, there is every reason to suppose that the joints at the lumbo-sacral junction have locked, or 'seized up', and in this event manipulation is indicated. If, however, movement in both directions is painful, the chances are that an inflammatory condition is present, and this indicates once more the need for rest, for support, or for both.

The locking of the joints between the articular processes of the vertebrae may take place in any region, but is most likely to occur where transitional vertebrae are present, and although it is quite possible for any of the joints between the articular processes in the lumbar region, or indeed in any other part of the spine, to lock, the most common situations in the lower part are at the lumbo-sacral junction and at the lumbo-thoracic junction.

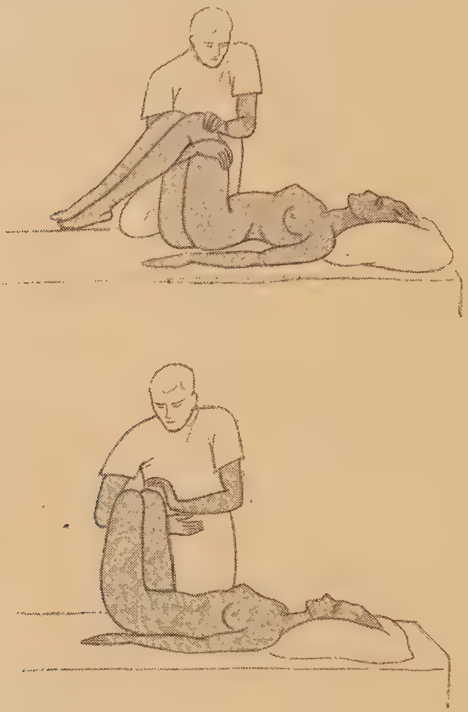


FIG. 45.—Method of side-bending of pelvis on trunk. The movement takes place mainly at the lumbo-sacral junction

(iii) The Lower Thoracic Region

In 'locking' at the lumbo-thoracic junction, the patient will complain of pain originating much higher up in the lumbar region, although it may extend right down the leg.

The main points in examination are:

Sitting

When sitting, stooping forward is relatively free, but this is due to rotation of the pelvis round the hip-joints, while the lumbar spine tends to remain immobile. Rotation of the trunk in the sitting position will cause pain in one direction but not in the other, or at least the movement will be more painful in one direction than in the other.

Standing

When standing a similar condition will be noticed.

If an inflammatory condition is present, then both in sitting and standing, forward flexion of the trunk and the return to the vertical have certain unmistakable signs. The downward journey is usually performed slowly and carefully, but is often quite complete; on the return journey, however, a curious movement is seen. The patient first raises the head, then the shoulders, and then, with the whole spine rigid, the trunk is rotated upwards around the hip-joints as if it were perfectly immobile. Having reached the vertical, the patient, often with a sigh, relaxes. Sometimes the movement both forwards and backwards is of this peculiar sinuous nature, which it is almost impossible to describe except by saying that it is exactly the movement that the patient would be expected to make when trying to 'skirt around' a position which he knows to be painful.

Lying

When lying, it is not certain that any particular movement will cause pain until the patient is placed prone, and then raising the trunk backwards from the shoulders and exerting counter-pressure over the joint affected will cause acute pain to be felt. Once again the treatment indicated is manipulation, but this must be avoided, or at least postponed, if active inflammation is still present.

(*d*) *X-ray Examination*

X-rays in diagnosis

No investigation of the joints of the back can be regarded as complete without X-ray examination. Moreover, an antero-posterior view alone is never sufficient; a lateral view should always be secured as well. Even if the apparatus is inadequate to give a perfect view, the attempt should still be made, as sometimes changes can thus be seen which prove invaluable from a diagnostic point of view, and even more so as regards treatment.

It is impossible to exclude bone disease with accuracy without X-ray examination, and it is equally impossible to detect some forms of injury, e.g. a crush-fracture of mild degree of the body of a vertebra, or fracture of the pedicles, which might lead to a spondylolisthesis.

As a result of clinical examination sacralization of the fifth lumbar vertebra, or lumbarization of the first sacral, may be suspected, but X-ray examination can not only prove either to be present, but also can show the extent to which they are present. The same applies to spina bifida occulta.

Interpretation of X-ray findings

Although X-ray examination is thus imperative in cases of long-standing backache, too much value must not be attached to some of the changes seen. For example, sacralization is not a contra-indication to manipulation, although it does indicate that a special technique is desirable, namely, that in no circumstances should any forcible manipulation which would involve the arching of the lumbar spine backwards be performed. Again, with lumbarization of the first sacral there is a tendency to instability of the sacro-iliac joint.

Arthritic changes should not be regarded as a contra-indication to manipulation. The presence of these changes merely indicates that an inflammatory process has been present, and that it was of sufficient severity and duration to lead to definite changes in bone and cartilage. The examination, however, does not provide information about similar changes in the soft parts, and often the symptoms of which the patient complains are due to these, and not to the changes in cartilage or bone. Many patients with these changes, even to a marked degree, are benefited very materially by manipulation.

3.–TREATMENT

(1)—By Manipulation

Essentials of manipulative treatment

During the foregoing description of examination, reference has frequently been made to treatment by manipulation, and treatment by support. So far as treatment by manipulation is concerned, all the ordinary laws of manipulation must be obeyed. It must first of all be ensured, so far as is possible, that any active inflammatory condition which may be present is due solely to trauma. So too if a non-traumatic arthritis has caused the symptoms, it is essential to be certain that the symptoms are due to pathological changes left by an inflammatory process no longer active in the joints.

It is then necessary to decide which joint it is desired to move, and in which direction the movement should be performed. Finally the posture of the patient must be so arranged that all other joints are fixed by moving them to the extreme limit of anatomical movement, before any strain is laid upon the one joint which it is desired to move. Whether it is possible to perform the necessary manipulation without an anaesthetic, must depend upon the severity of the symptoms. It is hardly ever necessary to exert great physical force during any manipulation, beyond the force required to overcome the body-weight of the patient. Provided it is clear what should be done, and how to do it, the amount of physical energy expended should be very slight, unless the patient is unduly tall or exceptionally heavy. Even so, the only force required is that which is sufficient to overcome the weight.

(*a*) *The Sacro-Iliac Joint*

Method of forward rotation

If the right sacro-iliac joint is locked in backward rotation, it is necessary to rotate it forwards. This can be accomplished directly, or by rotating the joint on the left side backwards and then moving the sacrum on the ilium of the injured side. In the sitting position this can be accomplished, on the right side, by locking the patient's hands behind the neck with the elbows forward. The operator, standing behind, passes his arm in front of the patient's chest and grasps the left upper arm; the patient leans backwards and the trunk is rotated to the right until the left ischial tuberosity is free of the couch. Counter-pressure on the anterior superior spine of the left side will rotate the left ilium backwards on the sacrum, and will then carry the upper part of the sacrum backwards on to the right ilium. This is the equivalent of saying that the crest of the right ilium is pushed forwards on the sacrum —a forward torsion-strain (see Fig. 46). This simple manœuvre often suffices for mild cases, and, indeed, frequently yields the type of result to which patients refer as a 'miracle cure'. The fixation point in this manipulation is that of the ischial tuberosity on the couch, while the mobilizing point is the sacrum. If, however, the symptoms are at all acute, the patient cannot tolerate the weight of the body being taken on the ischial tuberosity on the painful side, and other means must be chosen. The easiest method is that previously described during examination. The patient is placed in the side-lying position with the painful side uppermost; the upper thigh is flexed so that the knee is resting upon the couch; the trunk is then rotated backwards from the shoulder until the limit of movement is reached. Counter-pressure is then exerted forwards and downwards over the crest of the ilium. This is almost invariably successful but, should it fail, there still remains the chance of being able to effect the required end by placing the patient in the prone position, flexing the knee to a right angle, raising the thigh backwards from the couch and exerting pressure forwards and somewhat outwards on the back of the iliac crest.

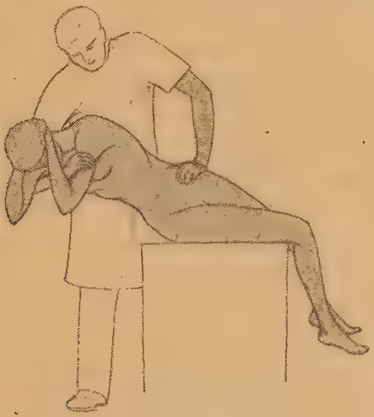


FIG. 46.—Method by which forward torsion-strain can be laid upon the right sacro-iliac joint

(*b*) *The Lumbo-Sacral Joints*

Relief of locking

Locking at the lumbo-sacral junction is usually relieved quite simply with the patient in the recumbent position, the hips being flexed to a right angle, and the knees flexed over the examiner's arm. If movement in one direction is more limited than in the other, it will be possible to restore mobility in the direction in which it is lacking by a sudden pressure when the limit of movement is reached. As a rule this manipulation is accompanied by a very loud snap in the joint, and relief and freedom of movement are often restored instantaneously.

In other joints, particularly at the lumbo-thoracic junction, it will sometimes suffice to place the patient in the prone position, raise the trunk, and exert counter-pressure directly downwards over the affected joint. This, however, is by no means invariably successful, and if it fails, the pain of the manipulation is often very acute. The difficulty is, that the patient in this position will often fail to relax sufficiently to allow the other joints to pass through to the limit of anatomical movement before the counter-pressure is exerted. Thus the muscle resistance which prevents movement to the anatomical limit merely acts as a spring. It is therefore often advisable to ensure that muscular relaxation is as complete as possible, by placing the patient in the all-fours position and asking him to arch his spine, copying as far as possible the movements of an angry cat. Unless active inflammation is present, this movement is almost invariably free, and it is movement in the opposite direction which should be carried out. Therefore, having arched to the full extent, the patient is asked to lower his back and allow the abdomen to approach as near as possible to the couch. This can usually be managed, and it is when movement has been carried to the fullest possible limit that counter-pressure downwards towards the couch will often secure the desired movement. Unfortunately the pain of this movement is often quite acute, and may even be followed by transitory symptoms of abdominal discomfort which the patient usually describes as a sudden, though very temporary, attack of flatulence.

Manipulation for local deviation of spinous process

Mobility cannot always be restored by simple backward flexion. Not infrequently careful examination of the contour of the sides of the spinous processes shows that there is a local deviation of one process to one side or the other. When this is so, manipulation in the side-lying position is required. The patient is placed in exactly the same position as that already described for the manipulation to exert a direct forward torsion-strain on the sacro-iliac joint, lying on the side from which the spinous processes deviate. The trunk of the patient is raised from the couch so as to be flexed acutely to one side. Counter-pressure is then placed upon the prominent spinous process in a direction downwards and towards the couch. It must, however, be remembered that it is necessary to fix the patient's trunk at the anatomical limit of movement before exerting the counter-pressure. The weight of the patient's trunk on the arm that raises it has no stable support unless something is placed between the couch and the arm that is carrying the weight. The simplest way to remedy this is for the flexed knee of the examiner to be placed in this space. He must, therefore, stand on one leg, and flexing the knee of his other leg to the full extent, rest his shin upon the couch. The patient's trunk is then raised and carried sideways until it rests on the front of the examiner's thigh, where it is held immobile by the arm that raised the weight. Fixation is now absolute, and any counter-pressure exerted will be directed to the one point at which pressure is applied.

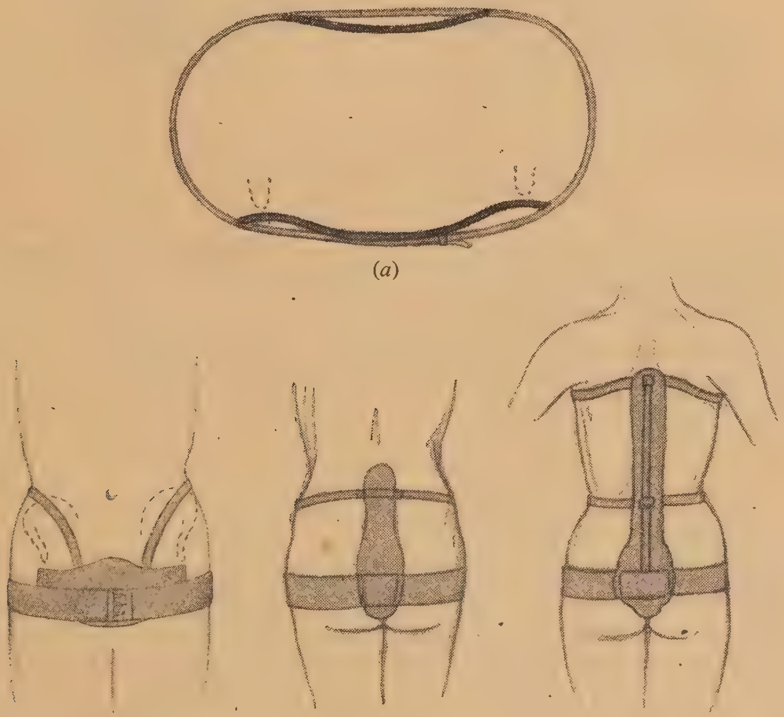
(2)—By Support

Belts

When the need of support for the sacro-iliac joint is indicated, the simplest form is provided by a two-inch horizontal webbing belt placed around the pelvis and arranged in such a manner that the main grip is taken just below the anterior superior spines of the ilia. As a prophylactic measure this may be all that is required, and it is of particular service in those cases in which manipulation has been practised in order to restore a lost mobility in the sacro-iliac joint. If, however, an inflammatory condition is present, and it is desired to support the joint more firmly, a low corset belt support becomes necessary. The best type is that which depends for its adjustment on a pulley strap, founded on the block and tackle system; but even then it is sometimes advisable to reinforce the support of the lacing with a two-inch webbing band placed horizontally round the pelvis.

Metal supports

In cases in which pain is at all severe, or relapse is frequent, even this is not adequate, and it is then necessary to reinforce the back of the corset with a metal plate or frame, and to add a shallow abdominal plate made of metal, narrowing at the outer ends to about one inch in depth. These ends, slightly padded, should rest just below the anterior superior spines of the ilia, and if a horizontal strap is placed over the two plates around the pelvis, a very rigid type of support will be provided (see Figs. 47 and 48).

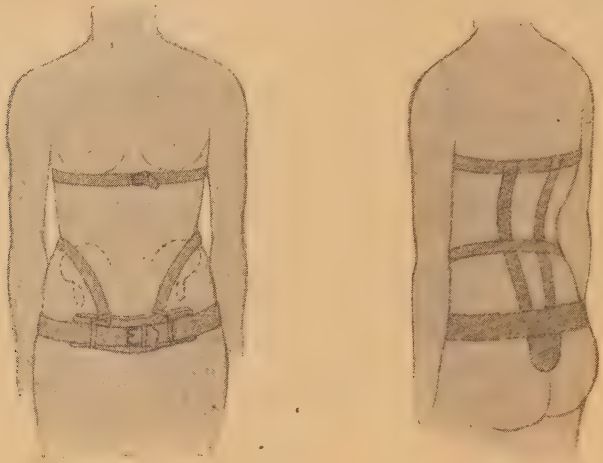


(a)

(b) (c) (d)

FIG. 47.—Sacro-iliac support (for details see text). (*a*) Shows the gripping effect of the front plate as described in text; (*b*) front plate; (*c*) and (*d*) types of back plates

A better result still is obtained if the whole can be incorporated in a corset of the type already mentioned. The whole apparatus is usually worn for some three months, and then, as the symptoms abate the front plate is discarded. A further interval of two months is allowed to elapse before discarding the back-plate, leaving only the belt support,



(a) (b)

FIG. 48.—(*a*) Front view of a 'spider' type of support particularly useful in postural cases needing support; (*b*) back view

which should be worn for at least two more months. The patient is instructed to return immediately to the full measure of support should there be the slightest return of symptoms.

If support is needed for the back higher up in the lumbar spine, this also can be arranged on similar lines, merely by altering the depth of the support and of the corset.

4.–ABNORMALITIES

Normal skeletal variations

In the lumbo-sacral region it is very difficult to say what should be regarded as normal in the skeletal structures. It is said, for example, that about one person in seven has a more or less sacralized transverse process of the fifth lumbar vertebra; or, again not uncommonly, the first sacral vertebra is lumbarized, or the fifth lumbar vertebra completely sacralized. These conditions must be considered as definitely outside the limit of the normal, but, even when no such definite abnormality exists, there are still variations to be noticed which extend between very wide limits. Thus in some patients the sacrum is set unduly low between the two ilia, so that the transverse processes of the fifth lumbar vertebra are confined in altogether too narrow a space. In other cases the sacrum is set too high. Then the fifth lumbar vertebra rides so high on the top of the sacrum that the ligaments, which attach the transverse processes to the pelvis, must slope obliquely downwards.

All these conditions are congenital and do not give rise to symptoms in the ordinary course of events. They must, however, like most congenital abnormalities, be considered as weak spots in the organism, which, if subjected to strain or accident, may give way. In these circumstances, disability and pain of the most intractable nature may be inaugurated. Presumably this is due to the fact that the ligaments in their original state are so arranged as to prevent any possibility of harmful movement. If, however, as the result of accident, these ligaments are stretched, even to a minute extent, the range of mobility normal to the individual is increased, and this increase is sufficient to cause trouble, in the very confined space in which it takes place.

Often support is all that is required to correct these conditions, but when this proves inadequate and pain or disability persists in spite of every endeavour to render support efficacious, or when there has been severe injury, the question of grafting and of other operations should be considered.

Skeletal abnormalities

Four abnormal conditions should be specially mentioned: sacralization of the fifth lumbar vertebra; spina bifida occulta; the condition in which the vertical depth of the spinous processes between the lumbar vertebrae is excessive and leads to the formation of a false joint between two adjacent processes; and spondylolisthesis.

(1)—Sacralization of the 5th Lumbar Vertebra

When one transverse process alone is sacralized symptoms may arise on either side. Their occurrence on the sacralized side is due to inflammation of the false joint between the transverse process and the sacrum, and X-ray examination may reveal arthritic changes in this joint. Pain, however, may be felt only on the side opposite to the sacralization, and the explanation is not at first sight clear. The fact is that the fixation of one transverse process tends to accentuate movement of the transverse process on the other side; and then the soft structures between the mobile transverse process and the sacrum may be 'nipped' severely.

Manipulation

As already noted, cases in which sacralization is present may call for, and benefit by, manipulation just as much as other cases in which this complication is not present. But (and this is most important) the technique employed must be entirely different, or far more harm than good will result. In the presence of sacralization the lumbar concavity must never be increased, and all manipulation must therefore be done with the lumbar spine flat or flexed forwards. In other words the lordosis curve must be obliterated throughout.

(2)—Spina Bifida Occulta

The cleft spinous process on one side is sometimes twisted upwards, may then impinge upon the process just above, and give rise to symptoms which correspond very largely to those present when the vertical depth of the spinous process itself is exaggerated.

(3)—Deep Spinous Process

This condition is liable to cause pain and distress to athletes, and particularly to tennis players who hyperextend their backs when serving.

Treatment

Often enough this troublesome disability can be overcome by altering the style of the service, although as a rule it is advisable to place a small light plate over the lumbar concavity in such a way that it will remind the patient, when he begins to arch his back unduly, that he must not go any further. Adjacent parts of two spinous processes may be removed successfully, so as to increase the space between them, if treatment by support fails.

(4)—Spondylolisthesis

This is usually attributed to a congenital defect in the arch of the fifth lumbar vertebra. It may also appear in advanced cases of osteoporosis. The body of the vertebra becomes detached from the arch and slips forward on the sacrum. A very disabling condition then arises, although the displacement does not seem to proceed far enough to cause symptoms due to actual pressure on the nerve-trunks. When fully established, and it is rare for patients to report for treatment when the slipping process has only just begun, the picture is unmistakable, as a sharp bony projection of the spinous process of the fifth lumbar vertebra is obvious. This is due to the slipping forward of the fourth vertebra which travels with the body of the fifth.

Treatment

Support is well-nigh impossible, and if, as so often happens, pain is disabling, there is no alternative to internal fixation. A posterior graft alone is inadequate: it is necessary to fix the bodies of the vertebrae from in front as well.

5.–POSTURAL DEFECTS

These may be considered under three headings: the lordosed back, the flat back, and the tilted pelvis.

Lordosis strain

It will be perfectly obvious that if the fifth lumbar vertebra is sacralized to any important extent, normal mobility between the fifth lumbar vertebra and the sacrum is seriously diminished. In these cases the angle at the lumbo-sacral junction is often accentuated and, if in addition mobility is reduced, a lordosis curve must of necessity be present to an extent which will, sooner or later, bring undue strain to bear upon the joints between the fourth and fifth lumbar vertebrae. In other patients increased weight of the intra-abdominal contents tends, not only to exaggerate the lordosis deformity, but also to stretch the muscles of the abdominal wall. These muscles must be considered as amongst the most important in maintaining the posture of the lumbar spine, and indeed it is no exaggeration to consider them as the anterior muscles of the spinal column. Chronic lordosis-strain from posture is therefore not uncommon and, when present, frequently causes pain in the lower part of the back, especially in those past middle age, and almost invariably in those with general visceroptosis.

The patient with lordosis strain gives a history of insidious onset, and often will accept the condition as part of the ordinary trials of existence, and not make any attempt to secure amelioration until pain is so severe that sleep is disturbed. The picture is unmistakable, even when the patient is fully clothed; the prominent gluteal regions and the well-marked hollow above tell their own tale. There is usually a compensatory kyphotic curve above, but this is not essential. The abdomen is generally prominent and often pendulous, and there is poor control over the muscular wall. The condition, however, may be seen in lean subjects with a flat abdomen.

The patient, as a rule, places the hands over the hollow of the back when indicating the area of the pain. When sitting, the lumbar spine does not flatten even on stooping, and there is tenderness between the spinous processes of the lumbar region. On leaning forward the tenderness is usually less than it is on leaning backwards, and all attempts at increasing the lumbar concavity accentuate the pain. These signs are equally prominent whether the patient is examined in the standing, side-lying, or prone positions. When recumbent the patient is not comfortable unless hips and knees are both bent. Raising the lumbar spine from the couch increases the symptoms, but otherwise all movements which do not entail increase of the lordosis curve are free and painless. It is in patients with this type of structural defect that symptoms so often arise after prolonged anaesthesia, if no precaution is taken to support the lumbar concavity.

Treatment of lordosis strain

Treatment is almost invariably by support, and the one essential is that the support should take its purchase from two points on the back, the first being over the sacrum, and the second over the lower thoracic region. The support will thus bridge, as it were, the lumbar concavity, the counter-pressure being taken over the lower part of the abdomen. The whole tendency of the support is then to carry the lumbar spine backwards towards the 'bridge'. Quite often the importance of providing this 'bridge' is not appreciated, and abdominal support is prescribed which takes its purchase from the apex of the lordosis curve, with the result that very many cases of backache date the origin of their trouble from the time when abdominal support of this type has been prescribed.

Flat-back strain

The picture of the patient with flat-back strain is also unmistakable. There seems to be one long C-curve from the top to the bottom of the back, and the coccyx has the appearance of being tucked away far too much between the legs. Any attempt to arch the spine backwards causes acute pain, but on the other hand the patient is able to stretch himself out absolutely flat on the couch and the lumbar spine is supported throughout its whole length. This is in marked contrast to the patient with lordosis strain, in whom the recumbent position can only be maintained, if at all, when both thighs are flexed to an angle of 60°. The flat-back strain, if sufficiently advanced, is a condition which it is often extremely difficult to correct, and the symptoms which arise from it are liable to be very intense.

Treatment of flat-back

Unless there are signs that active inflammation is present, treatment should consist of restoring mobility by manipulation, and this should be followed by support which aims at maintaining the lumbar concavity. Support applied to the back is often useless unless the patient is provided with relatively high heels. The reason for this will be considered presently.

Tilted pelvis

The tilted pelvis is due to inequality in the length of the legs. This is often congenital, or perhaps the result of severe trauma, and may exist throughout life without causing any symptoms. On the other hand it is obvious that if the pelvis remains raised more on one side than on the other, there must be some abnormal strain laid upon the joints in the lower part of the back, and very little irritation will suffice to cause symptoms to arise on the strained side. Sometimes it is sufficient merely to raise the height of the heel on the low side, but as a rule pain does not arise until stiffness has been established, and then mobility must be restored before the symptoms can abate. This very simple prescription of altering the height of the heels has cured many a patient of inveterate backache.

Defects of the feet

There are two other postural defects worthy of consideration which, though not situated primarily in the back itself, may yet cause symptoms in this region. These defects include the various foot deformities and insufficiency or loss of elasticity in the tendons and ligaments.

Loss of elasticity of the foot

Naturally, if the elasticity of the foot has been impaired, the spring which, in walking, spares the joints of the spine from jarring and irritation, has disappeared. The lack of this protection is responsible for very minute, but constantly repeated, traumas, which in turn may lead to a very mild, but no less chronic, inflammatory condition of the joints of the spine, and particularly in the lower part.

Short tendo Achillis

Again, if the trouble in the patient's foot should arise from an insufficiency of the tendo Achillis, so that he cannot adequately dorsiflex his feet, there is bound to be undue strain of the flat-back type in the lower lumbar spine, unless the deficiency is overcome by wearing an adequate height of heel. On several occasions the only thing which has brought relief to male patients with chronic backache has been the raising of the heels to over two inches. Needless to say this involves the making of a special last.

It is not difficult to understand why symptoms in the back arise from this condition, as the habitual posture of the individual with the short tendo Achillis is that which the normal individual adopts only when walking uphill, and most people have experienced the pain in the back which may thus be produced.

After the age of thirty-five or forty, elasticity throughout the body begins to diminish. As long as elasticity remains unimpaired, the insufficiency of the ligaments or tendons is of little significance, unless unduly marked; but once elasticity begins to fail, then the importance is considerably enhanced. Patients not infrequently discover that they are 'getting stiff', and attribute this to lack of mobility in the joints. They then endeavour to restore this lost mobility by exercises. Perhaps the most usual exercise in the 'daily dozen' is bending the trunk forwards with the knees straight in order to touch the toes—either sitting or standing. This is the exact equivalent of raising the legs from the couch with the knees straight when the patient is in the recumbent position, and, as has already been shown, this brings severe backward torsion-strain to bear on the sacro-iliac joints. One of the common causes of sacro-iliac trouble arising without definite history of trauma, in people past middle age, is the performance of this exercise. Cases characterized by most intractable pain, leading to severe incapacity, can sometimes be cured entirely by the simple expedient of omitting this single exercise and its equivalents from the daily routine. One of these equivalents is the long-sitting position with the knees straight and the trunk in the vertical. This is the position most commonly adopted in the early stages of convalescence when the patient is still in bed, and is first allowed to sit up. It is small wonder that, if strain is laid upon the sacro-iliac joints during the puerperium, after certain operations, or prolonged illness, this practice should be responsible for inflicting grievous bodily harm upon the individual. All that is required by way of prophylaxis is that the patient's knees should be bent, e.g. by placing a pillow under the knees, before he is allowed to sit up; the flat-back strain can often be prevented by the simple expedient of using a lumbar pillow.

'Motorist spine'

A modern type of low backache, which calls for special notice, is that associated with motoring. Many patients owe their pain and disability entirely to the posture assumed when driving a car. The seat is often set so far back that the driver has to assume what almost amounts to the long-sitting position, which, as already stated, is the equivalent of raising the legs with the knees straight while recumbent. The strain is accentuated in a car with heavy springs to clutch and brake. Severe strain is laid upon the sacro-iliac joints, and if to this is added the constant jarring of the seat when the joints are being forced backwards, it is easy to understand how trouble may arise. The remedy is to raise the height of the seat and to sit forward so that the knees are inevitably flexed throughout each journey, no matter how short. The ideal position for driving a car is that adopted by the London taxi-driver, who is seldom known to complain of the 'motorist spine'. Even passengers in a car who are not driving sometimes develop backache as the result of a long motor drive. This is due to the flat-back strain, associated with their posture, the sacrum being held too far forward on the seat, so that the lumbar spine is held in a position which can only be described as a reversed lordosis. So long as the muscles are sufficiently fresh to guard the joints from strain, all is well, but fatigue will inevitably occur in the course of time, and strain be laid upon the ligaments and the joints. The condition of the back is then the exact equivalent of the static flat-foot of adolescence, and symptoms may advance to a very acute state. The remedy is obvious, namely, to sling a small cushion on to the back of the seat, so that it fits exactly into the hollow of the back, some six inches above the level of the seat of the car.

Insufficiency of ilio-tibial band

Reference has already been made to the effects on the sacro-iliac joints and those of the lower lumbar spine when the elasticity of the ilio-tibial band is diminished from any cause. Short of dividing the band near the origin from the crest of the ilium, treatment should aim at stretching the band by means of massage and exercises. Often, however, there are sensitive deposits in the structure itself which are so painful that treatment on these lines is impossible till something has been done to render them less sensitive. The simplest method is to infiltrate with 1 per cent solution of procaine hydrochloride (novocain) and to needle this area freely. The usual sites for this treatment are near the crest of the ilium—especially near the posterior superior spine—over the great trochanter, at a point in the middle third of the outer aspect of the thigh, and in a similar position above the knee. Sometimes it may be necessary to deal in similar manner with sensitive areas below the knee and even as far as the ankle region. Subcutaneous infiltration with oxygen may be useful.

6.–THE MUSCULAR SYSTEM

It is surprising how often the diagnosis of 'torn muscle' is made in cases in which workmen are suddenly incapacitated by acute pain in the back. It is very seldom that rupture of muscle fibres takes place in other parts of the body, and it is quite inconceivable that the muscles of the back should be so extremely prone to this relatively uncommon injury.

As already indicated, these acute attacks of pain in the lower part of the back are constantly due to injuries of the joints, and adequate examination will prove how very seldom the muscles are directly at fault. It is perfectly true that much of the actual pain is often present in the muscles, but this is because they are thrown into spasm to prevent movement in the painful joint, and thus immobilize it. The pain is that of cramp, and exactly corresponds to the muscular pain experienced after fracture. There is only one sure way of discovering if a definite lesion is present in the muscle, and that is to provide rest and sedative treatment till the spasm has subsided, and then to examine the individual muscles with faradism. If contraction in response to the electric current causes definite and localized pain in the muscle, then we know that the muscle is at fault. Should this very definite sign be absent, the muscular system is intact.

Diagnosis of torn muscles

If this infallible test was applied regularly, the erroneous diagnosis of 'torn muscle' in the back would soon cease to be one of the most common errors of diagnosis. It will, however, continue to persist so long as examination with faradism is ignored.

Treatment of muscle injury

In those very rare cases in which definite muscle injury can be established as the result of faradic contraction, the treatment consists of rest and support. The direct treatment of the injured muscle is carried out by means of graduated faradic contraction and skilled massage, beginning around the periphery of the painful area and very gradually approaching it until the whole area involved can be treated without discomfort. Cure is established when full contraction in response to the current is painless, and when the muscle involved is placed in a condition of maximum tension.

7.–THE LYMPHATICS AND FIBROUS TISSUE

The sensitive deposits in the fascial planes which give rise to fibrositis are due to (*a*) dietetic error, (*b*) inadequate fluid intake, or (*c*) a focus of infection.

Fibrositis following dietetic errors

(*a*) Some individuals have learnt that a glass of port wine taken after dinner will result in pain in the back next day, and other forms of dietetic indiscretion may have a similar effect. Fortunately the symptoms are usually very transitory, provided that the error is not repeated; and any of the homely remedies, such as rubbing after a hot bath or the application of a hot-water bottle, will afford relief.

Following inadequate fluid intake

(*b*) Inadequate fluid intake is an entirely different matter, and when the cause has been operative over a considerable space of time, masses of sensitive deposits may be formed which can be removed only by long and hard work on the part of the masseur. Other forms of treatment are radiant heat, and particularly the infra-red ray lamp, but these should only be used as an aid to massage. If the massage is followed by a short dose of surging faradic contraction, it will quite definitely assist in the removal of waste products through the automatic massage of the lymphatic system, which is an inseparable part of alternate muscular relaxation and relaxation. Treatment, however, will not remove the deposits while the cause still persists, so that an essential part of the treatment is a copious fluid intake. By 'copious' is meant not less than five pints of harmless fluid a day.

Following infection

(*c*) When the sensitive deposits are due to the presence of a focus of infection, they must be regarded as 'metastatic'; and in these cases, for some reason difficult to explain, heat in any dry form is sometimes liable to cause an acute exacerbation of the symptoms, and even the most gentle massage sometimes serves merely to irritate. When the focus of infection has been removed these sensitive areas frequently remain and, provided that the utmost caution is exercised, they can as a rule be eradicated on lines similar to those prescribed for patients who derive their trouble from an inadequate fluid intake.

Backache from chills

There still remain two types of pain, due presumably to a similar cause, but of which the exact pathology is unknown. One is the backache that follows directly upon a chill. Even a very healthy person who lies down on damp grass after having climbed a steep hill is liable to suffer from severe backache next day. This kind of backache also follows sleeping in damp sheets, or sitting in a draught when heated. It can only be assumed that, in these cases, the chilling process results in contraction of the arterioles, and that this, by depriving the area of normal circulation, allows the accumulation of waste products. Although the condition may be so acute as to justify giving morphine, it is usually transitory and yields rapidly to heat applied in any form, the most suitable for an attack of moderate severity being probably a Turkish bath. If the attack is very acute, immediate relief will sometimes follow deep infiltration of the muscles with a local anaesthetic solution.

Very many substances have been tried externally, but the applications have to be 'rubbed in', and, as they each have firm advocates, it must be only the one element common to all, namely, the rubbing, that does the good. This does not mean that the application of rubefacients fails to bring a sensation of comfort, which is often of the greatest value. Counter-irritants undoubtedly have their place in treatment and therefore cannot be ignored. Still the fact remains that most of the conditions now under consideration are transitory in nature, and unless gross infection is present in some part of the body, the symptoms will abate, and the patient will recover, often in spite of the remedies, and not because of them.

Backache due to cutaneous hyper-sensitivity

Recent research has led to the discovery of a second condition, for which at present no satisfactory explanation is forthcoming. When no definite cause can be discovered for pain in a given situation, it is always well to test the cutaneous sensation of the area with faradism. A large pad is placed over one neutral area such as the abdomen, and, with the patient lying on his face, a labile electrode is applied to another neutral area, say the skin of the arm. The current is then increased until a definite tingling sensation is felt under the labile electrode. This is then applied to the area where symptoms are noted, and drawn over the surface of the skin. It will then be found that the normal sensation, as felt in the arm, will suddenly alter to an acute burning sensation. A mark is then made upon the skin and the area is approached from several different directions. In this way a definite area of skin hypersensitive to the current can be mapped out, and the application of a third-degree erythema dose of ultra-violet light to this area will often afford complete relief. The effect may be enhanced by the application of a galvanic current over the same area the next day. There can be little doubt that the benefit is due to the formation of histamine as a result of the application of the ultra-violet light. The lymphatics appear to be flushed, the area ceases to be sensitive to the current, and the symptoms disappear. In the present state of knowledge it can only be presumed that the sensitive areas are due to irritation of some minute nerve filament just before it breaks up into its terminal branches to supply the skin.

Treatment by ultra-violet rays

Sometimes examination with the current shows that the sensitive area is confined to a pin-point. The treatment already described is then liable to fail. Until quite recently it was thought that the correct treatment for this condition was the use of the galvanic needle, but the great disadvantage of this treatment is the extreme discomfort, often amounting to acute pain, which is associated with it. Other forms of treatment were the use of the actual cautery, or of the hot needle, and again the great disadvantage was the resultant pain. Now, thanks to the use of local anaesthetics, a treatment certainly no less efficacious, and often very much more so, can be administered painlessly. The technique is to anaesthetize the skin with a 4 per cent solution of procaine hydrochloride (novocain), and then, using a serum syringe, to pass the needle straight down into the sensitive spot and infiltrate the whole area with a 1 per cent solution. The needle is then passed in and out throughout the sensitive area, and up to one ounce of the solution may be used for the infiltration. After the needling has been performed freely, the treatment terminates with a vigorous application of any form of massage. The rationale of the treatment is that the current has revealed the presence of some minute spot of local irritation, probably in the form of an adhesion which has involved a nerve filament, and needling the spot may free this adhesion, or, if it fails to do so, the infiltration followed by massage may so stretch the adhesion that it ceases to annoy. These explanations are doubtless speculative and cannot be proved, but they may account for the fact that the most tiresome symptoms often disappear entirely almost immediately after treatment. There is often a sensation of bruising to be felt for a day or two, but this soon wears off, and relief from the symptoms is then complete.

Treatment by needling

8.–THE SUBCUTANEOUS TISSUES

Severe bruising or subcutaneous haemorrhage may be followed by the most intractable pain, sufficient to make life a burden. Presumably this pain is due to irritation of the nerve filaments passing through the subcutaneous tissues which are matted together as the result of the haemorrhage. Every movement of the skin then produces symptoms of traumatic neuritis. For this condition two remedies are available: cupping and subcutaneous infiltration of the area with oxygen (see Fig. 49). Sometimes one remedy seems to be more effective than the other, but there appears to be no certain guide as to which should be the treatment in any given case. On the whole, however, it may be taken that there are two methods of reproducing pain due to this cause. One is by direct pressure over the area; the other by picking up the skin and pulling it away from the underlying structures. If it is then found that pressure causes the greater discomfort, oxygen infiltration will be the treatment to select. If on the other hand the picking up of the skin is the more painful, then cupping should be given priority. The area to be treated is covered with soft paraffin and the cup is applied so as to adhere firmly. Constantly exerting tension away from the part, the operator draws the cup along the

Methods of treatment

Cupping

Choice of treatment

surface, thus raising the skin with a wave-like motion. Errors will no doubt be made in the choice of treatment for this condition, but there is this consolation, that if one fails the other is well-nigh certain to succeed, and, in fact, in some very severe cases a combination of the two remedies seems to be essential.

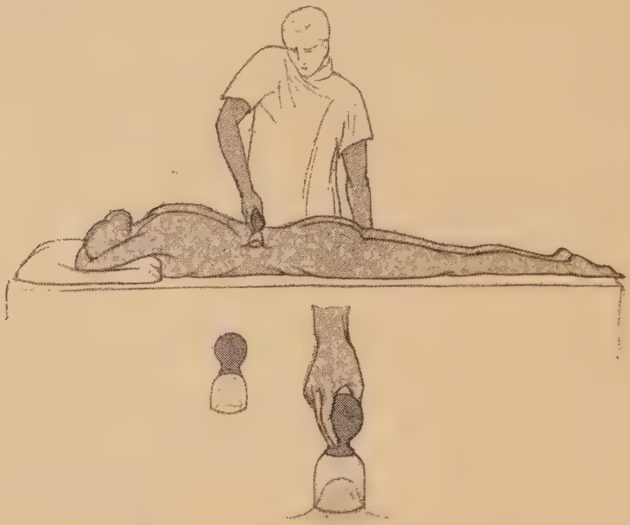


FIG. 49.—Correct use of the cupping glass

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BAGHDAD BOIL

See LEISHMANIASIS, CUTANEOUS

BAKER'S ITCH

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Reference may also be made to the following titles:

ALLERGY SKIN DISEASES: OCCUPATIONAL DISEASES

118.] Baker's itch is an occupational eczema occurring in bakers.

1.–AETIOLOGY

The condition occurs chiefly, though by no means exclusively, in bakers who knead dough by hand, and nearly always after they have been many years in the trade. The cause is in many cases unknown. The ingredients of dough are flour, salt, yeast and water. In a very small percentage of cases flour is undoubtedly responsible; and in these the application of flour, dough, wheat glutenin or gliadin to the unbroken skin for twenty-four hours is followed either immediately or after an interval of one to three days by an erythematous or erythemato-vesicular reaction at the site of the application. In the great majority of cases, however, no such reaction follows this test. *Irritation*

Efforts have been made to discover some cause other than flour. Yeast is evidently not a factor, as numerous tests for sensitivity to this substance have been made with uniformly negative results. Nor is sodium chloride or sodium bicarbonate responsible. On the other hand, ammonium and potassium persulphates, which are used as flour improvers, have been so considered. But the great majority of patients do not exhibit allergic sensitivity when flour, dough or any of the ingredients of dough are applied to the skin in patch tests. Thus, excluding the rare cases of sensitivity to ammonium and potassium persulphate, the cases must be divided into two groups: those in which the dermatitis is provoked by the proteins of flour, and those in which it occurs in the absence of sensitivity to flour, yeast or any of the salts used in 'improving' flour or baking.

Hyperidrosis

In common with many cases of dermatitis in occupations other than baking, the sufferers are often found to sweat excessively. Bakers work in a very hot atmosphere and the combination of heat and hyperidrosis is undoubtedly capable of damaging the protective horny layer of the skin. Dough sticks to the hands and forearms and its removal after drying requires a certain amount of force; and the salts may also exert an irritant action. It is possible that the skin may thus be subjected to many repeated small insults and eventually break down, just as it often breaks down in housewives who are exposed to nothing more irritating than soap and water. It is significant that the breakdown generally takes place in the fifth and sixth decades, when the vitality of the skin is diminishing.

2.—CLINICAL PICTURE

The acute form

The eruption resembles the dermatitis provoked by plants, and consists of erythema and swelling of the dorsal surface of the hands, the wrists and the exposed parts of the arms, followed by superficial vesiculation or coarse blistering. The face may also be a site of acute erythema often accompanied by oedema of the eyelids. In this type allergic hypersensitivity to flour is found, and on stopping work the swelling rapidly subsides and is followed by desquamation. Within about a fortnight the skin resumes its normal appearance. Recurrences are not probable if the bakehouse be avoided.

The chronic form

In the far commoner chronic variety, the dermatitis resembles in every particular that provoked by a number of other common irritants, e.g. formaldehyde, lime, soda and turpentine. Itching is experienced first on the hands, wrists and fingers, but sometimes occurs predominantly on the softer skin of the arms, stopping at the elbows or the level of the rolled-up portion of the shirt sleeve. Within a few days small eczematous vesicles appear on part of the affected region, particularly the fingers; these vesicles become opened by trauma and leave tiny pits from which serum exudes or which become covered with crusts. The vesicular and weeping phase may be absent especially on the arms, where the eruption may consist of irregular spots, patches or large dry scaly areas. Under suitable treatment, including cessation of work, the eruption slowly improves but may not clear up entirely for many months. Scratching to allay irritation often gives rise to patches of lichenification which are very rebellious to treatment.

3.–COURSE AND PROGNOSIS

The acute form

In the acute type of baker's itch in which sensitivity to flour is found, the eruption disappears rapidly after cessation from work and shows little tendency to recur if some other occupation be followed. Unfortunately by the time the condition develops the patient is often too old to take up any other reasonably remunerative work.

The chronic form

In the chronic cases in which sensitivity to flour is absent, the outlook is often unsatisfactory although a great deal of improvement quickly follows cessation of work; but almost any rough manual work is liable in these cases to provoke a fresh attack. The eruption is often prolonged indefinitely by scratching and rubbing to allay irritation and in some cases the dermatitis never quite disappears. It is therefore never safe to promise a complete recovery.

4.–DIFFERENTIAL DIAGNOSIS

Eczema of the hands and arms in a baker is objectively the same as eczema in the same regions whatever the cause, and occupation cannot be accepted as the cause without a meticulously careful inquiry. A complete examination of the patient may prove that he is suffering from eczematized scabies. In certain cases of the asthma-eczema-complex cutaneous lesions may be found predominantly on the upper extremities. In such cases there will be a history of eczema in other regions—generally the face—in infancy or childhood, and sometimes a history of asthma, The patient may spend his leisure in gardening or in some other occupation in which there is a possibility of contact with some eczematogenous irritant. The difficulties in arriving at a positive conclusion are sometimes almost insuperable.

5.–TREATMENT

The treatment of baker's itch is that of dermatitis in general. Local remedies consist of lotions in the acute erythematous cases or in the early vesicular phase of the more chronic type.

Calamine Zinc oxide	of each 30 grains
Glycerin Lime water Water	of each equal parts to 1 ounce

or dilute solution of lead subacetate B.P. may also be used.

Cold boiled water soaks applied every hour are of value at this stage, and may be replaced when desquamation follows by the compound calamine liniment B.P.C., or a cream such as:

Zinc oxide Olive oil	– of each	1 ounce
Anhydrous wool fat –	–	120 grains
Lime water –	– –	6 fl. drachms

The indolent phase

In the chronic indolent phase no local application is more satisfactory than crude coal tar applied in the form of

Crude coal tar	– –	15 grains
Zinc oxide Starch	– of each	90 grains
Soft paraffin –	– –	to 1 ounce

Small doses of X-ray are of value in clearing up rebellious lichenified areas.

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BALANITIS

By Brevet-Col. L. W. HARRISON, D.S.O., M.B., F.R.C.P.Ed.
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Medical School, London

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1. SIMPLE BALANO-POSTHITIS – – – 285
2. EROSIVE AND GANGRENOUS BALANITIS – 286

Reference may also be made to the following titles:

CHANCROID GONORRHOEA SYPHILIS

119.] Balanitis is an inflammation of the surface of the glans penis usually associated with posthitis, or inflammation of the lining of the prepuce, the combined condition being known as balano-posthitis. It occurs in two main forms: (i) simple, and (ii) erosive and gangrenous, of which the simple is by far the commoner. Both affect only males in whom the prepuce is long and phimotic so that the prepuce encloses a sac with a moist and softened lining which is an excellent incubating medium for micro-organisms. *Definition*

1.–SIMPLE BALANO-POSTHITIS

Simple balano-posthitis is usually due to retention of secretions within the preputial sac—e.g. of smegma, urine in cases of diabetes mellitus and gout, and discharges from chancroidal or syphilitic sores or from the urethra in gonorrhoea. It may also occur as a complication of herpes progenitalis. The exact part which micro-organisms play in the causation is uncertain. The discharge resulting from the inflammation teems with organisms of the kinds commonly found under the prepuce of normal individuals—staphylococci, streptococci, diphtheroid bacilli, perhaps *B. coli* and spirochaetes of various kinds. The first four of these are commonly found in the urethral secretion of patients with non-gonococcal urethritis and it seems probable that, although they normally lead a vegetative existence about the urethral entrance and in the genital passages of females, one or more of them may become pathogenic in such favourable conditions as those under a phimotic prepuce. Apart from the cases in which balanitis complicates gonorrhoea, chancroid and syphilitic sores, it probably occurs most frequently in young adolescents *Aetiology* and others who have not yet learnt to keep the preputial sac clean. After these, diabetic and gouty subjects are most liable to be affected.

Clinical picture

In its simplest form balanitis causes a feeling of burning and itching, accompanied by some discharge of white pus with a sickly odour. The lining of the prepuce is reddened and swollen, and there is also more or less generalized reddening of the glans. In more severe forms there is some erosion and even ulceration of the surface of the glans and coronal sulcus.

Sequelae

As the result of simple balanitis and posthitis in elderly subjects, a condition may develop on the inner surface of the prepuce and on the glans, closely resembling leukoplakia as met with on the tongue and the vulva. Another sequel may take the form of a slowly progressive sclerosis of the prepuce causing acquired phimosis, which may eventually lead to a pin-point opening at the end of the thickened foreskin. There is no evidence to show that either of these conditions is a precursor of malignant disease, but they may both be associated with the development of that condition.

Diagnosis

Diagnosis of the simple, uncomplicated condition is easy. The prepuce need only be retracted and the urethral meatus cleansed and examined to avoid the mistake of diagnosing the condition as gonorrhoea. As mentioned above, balano-posthitis commonly accompanies chancroidal ulceration, syphilitic lesions and herpes, and these conditions should be carefully looked for in every case.

Treatment

The treatment of simple balano-posthitis is to remove the irritant by frequent retraction of the prepuce and the use of a mild antiseptic lotion. Syringeing out the sac with solution of hydrogen peroxide (5 volumes or stronger) usually acts well and is particularly useful when the prepuce cannot be retracted. When balano-posthitis complicates chancroidal or syphilitic lesions, it usually subsides when these heal. Circumcision, being a perfect prophylactic, should always be considered, if not at once, at least after subsidence of the inflammation. When the prepuce is very painful or can be retracted only with great difficulty, the desirability of making a dorsal slit and completing the circumcision when the inflammation has subsided may be considered.

2.–EROSIVE AND GANGRENOUS BALANITIS

Aetiology

Erosive and gangrenous balanitis, sometimes called 'the fourth venereal disease', are different degrees of a condition resulting from infection of the preputial sac with the fusiform bacilli and coarse spirochaetes that elsewhere are responsible for Vincent's angina. It is not common and is believed to be often due to contamination with infected saliva as would occur in certain sexual practices. The organisms flourish under anaerobic conditions so that the tighter the preputial orifice, the more severe the attack. Conversely, the more freely the parts are aerated, the more quickly is the disease arrested.

Clinical picture

In the milder, erosive type, the epithelium flakes off in areas of varying size leaving superficial erosions. On retraction of the prepuce one or more greyish-white patches are seen on the lining, in the coronal sulcus and on the glans. The process may stop at this stage but in more severe cases, especially when anaerobic conditions are more favoured by a tighter prepuce, ulcers appear varying in size from that of a pin's head to that of a pea or even larger, covered with a yellowish-white or brown diphtheritic membrane, and with an irregular, inflammatory border. The ulceration may extend in area and depth and cover the surface of the coronal sulcus, the preputial lining and the glans. In still worse cases the ulcers become gangrenous, the prepuce becomes black and sloughs, and the whole penis is greatly swollen. Gangrene may spread deeply into the glans and even through the whole penis and lead to loss of this organ. The discharge from the prepuce in the mildest cases is thin, yellowish-white and extremely offensive. In the ulcerative cases it is more profuse, and in gangrenous cases it is greyish-yellow or yellowish-brown, sometimes haemorrhagic and still more foul-smelling.

The constitutional symptoms vary in severity with that of the local condition. In the ulcerative cases the temperature range is to 100° or 101° F. In the gangrenous cases the temperature may reach 104° F., and be associated with vomiting and corresponding constitutional disturbance.

Differential diagnosis

The diagnosis from chancroidal or other ulceration is difficult if the prepuce cannot be retracted, but the condition should be suspected if the preputial discharge is thin, yellowish-white and offensive, and contains fusiform bacilli and spirochaetes. If the ulcerative and gangrenous type is suspected and the prepuce cannot be retracted, it should be divided by a dorsal incision, or a broad V should be removed from its dorsum. Exposure of the parts in this way not only favours accurate diagnosis but also prevents further erosion or gangrene.

Treatment

The treatment of erosive balanitis is aeration of the preputial sac, and solution of hydrogen peroxide is rightly regarded as a specific for the condition. This solution (5 volumes or stronger) can be injected into the preputial sac every hour or even more often, depending on the severity of the attack. As mentioned, however, exposure of the parts by incision is indicated if the balanitis does not respond promptly to hydrogen peroxide or if it has been allowed to become ulcerative or gangrenous.

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BALDNESS

See ALOPECIA, Vol. I, p. 337

BALNEOLOGY

See HYDROTHERAPY

BANTI'S SYNDROME

See ANAEMIA, Vol. I, p. 450

BARBER'S RASH

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Reference may also be made to the following title:

IMPETIGO

(*Synonym.*—Sycosis barbae)

120.] Barber's rash is a pustular follicular affection of the beard and other hairy parts.

1.–AETIOLOGY AND PATHOLOGY

The term barber's rash has no precise definition, but it is applied usually by laymen to the pustular follicular affections of the beard more correctly known as sycosis barbae. Apart from the face, which is its most common site, sycosis is found on the scalp, eyebrows, and the nape of the neck; it is occasionally accompanied by a pyogenic infection of the pubes, axillae and other parts bearing stout hair. Even when the beard alone is attacked it is rarely due to the cause that the name barber's rash suggests. It is a simple pyogenic infection of the hair follicles by the *Staphylococcus aureus*, and occurs chiefly in adolescent and adult males. The eyebrows and scalp, however, may be the seat of the same affection in women and children. *Site of rash*

Disposing conditions

An important disposing cause is the constitutional state of the skin known as seborrhoea, upon which most pustular infections flourish The combination of a stout beard and a tender skin may also be a factor Chronic catarrhal rhinitis is responsible for many cases of sycosis of the upper lip and eyelashes. In an important group of cases the infection dates from an attack of measles or some other catarrhal infection of the upper respiratory tract in childhood. The impetiginous rhinitis and fissured impetigo of the nose and ears which may follow such conditions are occasionally complicated by blepharitis, catarrhal impetiginous dermatitis and staphylococcal folliculitis of the scalp. The blepharitis especially has a tendency to persist and to be later the starting point of sycosis.

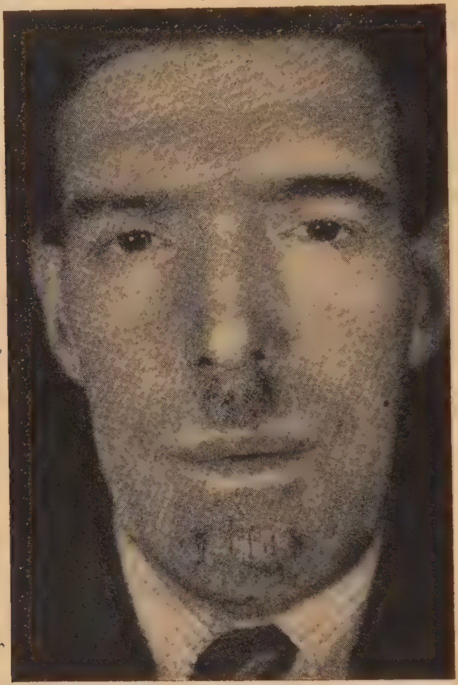

FIG. 50.—Sycosis of upper lip and chin, with infected cystic lesion on left lower eyelid

These children appear to be predisposed to pyogenic infections or to lack resistance to them, a condition which often persists throughout life. There can be little doubt that malnutrition and bad hygienic conditions are contributory factors in sycosis; the condition is certainly seen most often among the poorer classes in crowded communities.

Histology

The histological researches of Sabouraud have demonstrated that the pustule of sycosis is superficial. In the acute form of superficial staphylococcal folliculitis (Bockhart's impetigo) the pustule is cast off in the form of a crust by the restitution of the epidermis from below. In sycosis, while a pustule is in the process of being evacuated in this way, another has invariably begun to form beneath it. According to Sabouraud this explains why sycosis can persist indefinitely without determining scars and the destruction of the hair follicle. But so far no one, he says, has explained why spontaneous exfoliation of the crust should cure the majority of other staphylococcal follicular infections but not sycosis.

2.–CLINICAL PICTURE

The lesions may be discrete, papular, papulo-vesicular or tuberous; more commonly there are confluent pustules situated on a diffuse infiltrated reddened base, or a diffuse redness with a tendency to the formation of crusts may be present without obvious pustules.

The following varieties are distinguished:

Sycosis of the face

Sycosis of the face is often preceded by some accidental infection of one of the cheeks or the chin, often impetigo contagiosa; upon this, a primarily streptococcal infection, a secondary staphylococcal infection of the hair follicles becomes implanted. In other cases the infection is a folliculitis from the beginning. Infected razors, shaving brushes and towels are no doubt responsible for some of these cases.

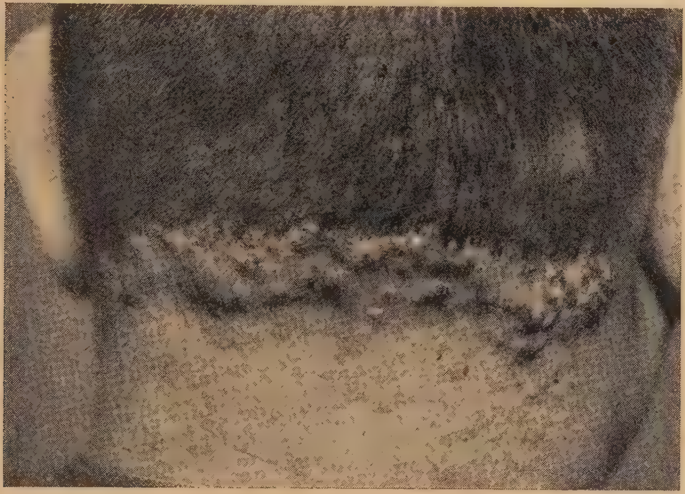

FIG. 51.—Sycosis nuchae—dermatitis papillaris capillitii (Kaposi). Case of Dr. A. E. Silcock

Sycosis of the upper lip

Sycosis of the upper lip is usually associated with chronic nasal catarrh. The infection of the moustache is often preceded by fissures in the angles of the nares, by infection of the vibrissae or sometimes by blepharitis (see Fig. 50). In one type the blepharitis has persisted from childhood.

Sycosis of the scalp

Sycosis of the scalp is seen most often in children. Beginning as impetigo, or complicating pediculosis capitis, or spreading upwards from a fissured impetigo of the ears, the infection first invades the scalp in the form of catarrhal dermatitis; upon this a chronic staphylococcal infection of the follicles is secondarily grafted. Sycosis of the scalp is also seen in adults though rarely: very occasionally it is accompanied by a progressive cicatricial alopecia.

Sycosis nuchae

Sycosis nuchae is a fourth variety. The nape of the neck is especially liable both to furunculosis and chronic staphylococcal folliculitis. The latter occurs chiefly in obese subjects with thick necks. Friction of the collar appears to determine the site of the infection in some cases, but in others the folliculitis is above the part which is rubbed in this way; in others intertriginous friction of the redundant skin may be the determining factor. Occasionally the chronic follicular infection is accompanied by fibrous proliferation, the pustules being converted by this process into small hard nodules, or when confluent into a horizontal irregular fibrous band. When this occurs the condition is spoken of as dermatitis papillaris capillitii (Kaposi). This is shown in Fig. 51. The same change may accompany pustular acne of the nape of the neck.

Lupoid sycosis

Lupoid sycosis is rare and usually occurs on one cheek; it differs from ordinary sycosis by a tendency to extend very slowly, and by cicatricial destruction with permanent alopecia of the central portion of the lesion.

Generalized sycosis

In generalized sycosis the scalp, eyebrows, eyelashes, beard, and upper lip are all attacked, and pyogenic infection may occur on other hairy parts such as the pubes, axillae, and the extensor aspect of the forearms and lower limbs. Many patients have suffered from childhood from the type of staphylococcal infection of the scalp, eyebrows and eyelashes already described.

3.–COURSE AND PROGNOSIS

Sycosis shows little tendency to spontaneous cure, but cases vary greatly in their responsiveness to treatment: the earlier and more localized the case, the greater the probability of complete cure. If the condition has been established for a year or longer, the prognosis is uncertain. Among the more unsatisfactory are the cases which have begun in childhood as an infection of the scalp and eyelashes; in these the beard is often attacked in adult life. Ciliary sycosis alone, especially if accompanied by chronic nasal catarrh, may also be complicated in adults by intractable sycosis of the upper lip, and sometimes of the beard generally.

The most rebellious form of all is that in which all hairy parts are attacked. In many of these the infection of the scalp, or blepharitis, has been present from childhood.

4.–DIFFERENTIAL DIAGNOSIS

From Bockhart's impetigo

It is not always easy to differentiate sycosis from the orificial pustular folliculitis known as Bockhart's impetigo. In the latter, however, the pustules are always discrete and are usually larger and more tense than in sycosis; moreover they undergo spontaneous cure. The pustule in Bockhart's impetigo is invariably superficial, and if hair is withdrawn from an infected follicle a small bead of pus is often found attached to it at about the level of the orifice of the follicle at some distance from the root. In sycosis the infection is also present mainly at the point of emergence of the hairs, the majority of which resist traction as stoutly as normal hairs. But here and there in sycosis will be found a deeply infected follicle from which the hair surrounded by its root sheath can be withdrawn without appreciable resistance. On the scalp or on the face in an adult male an attack of Bockhart's impetigo must be regarded with suspicion, for if the first attack be followed by recurrences, sycosis may in due course supervene.

From tinea sycosis

In trichophytic folliculitis (tinea sycosis) the lesions are at first perifollicular pustules, like those of sycosis, but they quickly become tuberous and by confluence they usually form raised indolent plaques or tumours.

Lupoid sycosis may resemble lupus vulgaris and tertiary syphilis.

5.–TREATMENT

General hygiene and rest

No general treatment can be applied to all cases of sycosis but any defect in the general state of the patient must receive attention. In early cases with debility from such causes as malnutrition, overwork or alcoholism, a long holiday in the open air may be of great value. Vaccines have been employed for many years but have not proved reliable. Staphylococcal toxoid has also failed as a remedy for sycosis in spite of a few early reports of successes.

Local treatment

The local treatment is all-important. It is first necessary to stop shaving, keeping the hair cut as short as possible with scissors. Crusts must be removed by starch and boric acid poultices or antiseptic compresses. The following modification of D'Alibour's water is a suitable preparation for this purpose:

Copper sulphate – – –	2
Zinc sulphate – – –	7
Camphor water – – –	300

to be diluted with 5 to 10 parts of water for use as a lotion.

When the crusts have been removed the improvement is often striking but progresses no further. In early cases it is sometimes possible to complete the cure by the application of one of several preparations. A 3 to 5 per cent solution of silver nitrate applied daily has proved more successful in the writer's hands than any other preparation. Brilliant green, 1 per cent in 10 per cent alcohol has also been used with some success.

Sabouraud recommended the application twice daily of

Precipitated sulphur – –	1
Fresh lard – – –	30

Epilation

In well-established cases it is necessary to epilate the infected areas by X-rays. In the majority this proceeding is followed by complete relief from symptoms but in some a close observation of the affected parts reveals bluish or faint red patches which indicate that the infection persists below the surface. It is impossible to forecast the result of a single epilation in sycosis; in some cases, complete and permanent cure follows, but in others regrowth of the hair is followed, either immediately or after a short period of freedom, by relapse.

Sabouraud recommended after the first epilation the continual removal of the hair, including down, by forceps; this should be done by a trained epilator, or in very localized cases, such as those which occur on the upper lip, by the patient. At the same time the whole of the affected area should be treated by the sulphur ointment mentioned above. Although shaving the affected part is permitted, the shaving brush should be boiled or left in an antiseptic, and the beard should be subjected to a friction with an antiseptic after shaving—e.g. D'Alibour's lotion or 1 per cent solution of iodine in 70 per cent alcohol.

In sycosis of the upper lip, nasal catarrh, if present, should be treated by washing out the nasal cavity twice daily with saline.

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BARCOO ROT

See VELDT SORE

BARLOW'S DISEASE

See SCURVY

BARRAQUER'S DISEASE

See LIPODYSTROPHIA PROGRESSIVA

BARTHOLIN GLAND

See VULVA AND VAGINA DISEASES

BARTONELLOSIS

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2. VERRUCA PERUVIANA (LOCALIZED BARTONELLOSIS) - - - - - 298

Bartonellosis is met with in two clinical forms—namely, (1) Oroya fever (generalized bartonellosis), and (2) Verruca peruviana (localized bartonellosis). These two conditions were formerly thought to be distinct, but it was definitely established by Noguchi that they were but different phases of infection with one and the same organism, *Bartonella bacilliformis.*

1.–OROYA FEVER (GENERALIZED BARTONELLOSIS)

(*Synonym.*—Carrion's Disease)

121.] The first stage, generalized bartonellosis or 'Oroya fever', formerly known as 'Carrion's disease', is an acute specific fever which is found in certain valleys of the western slopes of the Andes between the 9th and 11th parallels of South Latitude at an elevation of 3,000 to 10,000 feet. It is found in Peru, Ecuador, Bolivia and Chile; and its range is remarkably restricted, for it is confined to certain narrow and hot ravines, while the inhabitants in the immediate vicinity are exempt.

The term 'Carrion's disease' refers to an incident in 1885 when Daniel E. Carrion, a Peruvian medical student, contracted a fatal attack of this fever by inoculating himself with blood from a verruca nodule.

Aetiology

During the fever *Bartonella bacilliformis*, rod-like, slightly curved bacillary organisms, 2μ in length by 0·5μ broad, often branching and in chains, and staining an intense blue with Romanowsky's stains, are found in the interior of the majority of the red blood corpuscles, and in the endothelial cells of the lymph glands (see Fig. 52). They somewhat resemble stages of a piroplasma (*Theileria parva*) during its cycle in the lymphatic glands.

Other forms of *Bartonella bacilliformis* are rounded bodies 1μ or less in diameter, usually oval or pear-shaped, and containing chromatin granules. In fresh blood both forms are visible and show feeble independent movements.

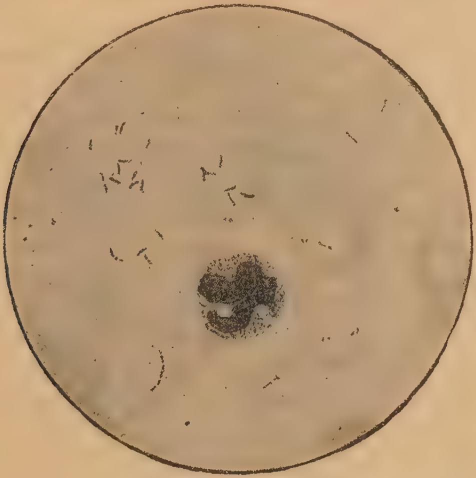

Fig. 52.—*Bartonella* bodies in the red cells of the blood from a case of Oroya fever

(From *Practice of Medicine in the Tropics*, Byam and Archibald)

Cultivation of organism

Noguchi, regarding *Bartonella* as a bacillus, succeeded in culturing it on blood-agar media. Battistini's method of culture is comparatively simple. A small drop of the patient's blood is withdrawn on to serum-agar. The end of the tube is sealed in the flame and incubated at 28° C.; colonies become visible in 5 to 6 days and the cultivated organisms are 0·6 to 1·6μ in length. *Bartonella* is an obligatory aerobe and Gram-negative, but stains well with Giemsa and Romanowsky stains. Intravenous injection of cultures into *Macacus rhesus* monkeys produces irregular fever and extreme anaemia, while intradermal inoculation into the supraorbital tissues gives rise to verruca nodules. Under experimental conditions Noguchi succeeded in conveying infection to monkeys by the bites of ticks (*Dermacentor andersoni*). These observations were later confirmed by Mayer and Kikuth and others.

Vector

In 1913 Townsend conjectured that the natural insect vector is a species of sandfly—*Phlebotomus verrucarum*—and succeeded in transmitting the disease to monkeys by inoculating emulsions of sandflies caught in the endemic area of the disease.

Seasonal incidence

In Peru the disease is most prevalent from January to April, when the rivers are in full flood, the air is warm and moist, and insect life most abundant.

The outstanding pathological feature of Oroya fever is the rapidity

Blood picture

of the blood destruction. In extreme cases the red blood count may be reduced to one-tenth, i.e. 500,000 cells per c.mm. The blood picture may resemble that of the most severe Addisonian anaemia, the majority of cases being of the megalocytic type. There is also a marked leucocytosis and disappearance of the eosinophil cells.

Tissue changes

The liver, spleen and bone-marrow show very definite changes. In the liver there are areas of degeneration and necrosis, particularly around the hepatic veins, and haemosiderin pigment is present in abundance. The spleen is enlarged and contains necrotic areas and pigment. The lymphatic glands contain large endothelial macrophage cells studded with rod-shaped *Bartonella* bodies. The bone-marrow shows necrosis and well-marked phagocytosis of *Bartonella* bodies by the endothelial cells.

Clinical picture

The incubation period of Oroya fever lasts about three weeks. The onset is gradual, a period of malaise and irregular fever being followed by rapidly developing anaemia and pains in the head, joints and long bones. The initial fever often resembles that of malaria, but the most severe types resemble an acute typhus with enlarged and tender liver and spleen. A terminal delirium is often noted and the disease ends within two or three weeks. The death-rate varies from 10 to 40 per cent.

Mortality

2.–VERRUCA PERUVIANA (LOCALIZED BARTONELLOSIS)

Definition

122.] The verruca or eruptive stage ('localized bartonellosis') follows recovery from the acute Oroya fever, or it may ensue gradually without the occurrence of primary fever.

Verruca peruviana may be defined as a granulomatous eruption confined to Peru and neighbouring countries, and superficially, at any rate, the verruca lesions resemble those of yaws (see Fig. 53).

Aetiology

Noguchi succeeded in reproducing verruca lesions in monkeys and in demonstrating *Bartonella* bodies within these lesions. His work was confirmed by Mackehenie, Weiss, Mayer and Kikuth.

Morbid anatomy

Primarily the changes consist of a proliferation of the lymphatic endothelium, the lymphatic channels soon becoming obstructed by plasma cells and fibroblasts. Collections of fibroblasts form nodules around the blood-vessels. It is interesting to note that monkeys with *localized* bartonellosis (verruca), in which prominent nodules are present, rapidly develop *generalized* bartonellosis (i.e. severe anaemia and other symptoms of Oroya fever) when subjected to splenectomy.

Clinical picture

The incubation period of verruca subsequent to Oroya fever is 30 to 40 days, but when the initial fever is absent it may be as long as 60 days.

The initial stages are accompanied by rheumatic pains similar to those of yaws; and the eruption, also like that of yaws, may be sparse, discrete or confluent.

Some granulomas may continue to increase, whilst others wither and drop off without leaving a scar. The eruption is either miliary or nodular; the former is found most abundantly on the face and anterior aspect of the extremities, but is less common on the trunk.

In verruca, vascular lesions may develop on the mucous surfaces, in the mouth, oesophagus, stomach, intestine, bladder or vagina. These lesions account for the dysphagia, haematemesis, melaena and haematuria which accompany this disease.

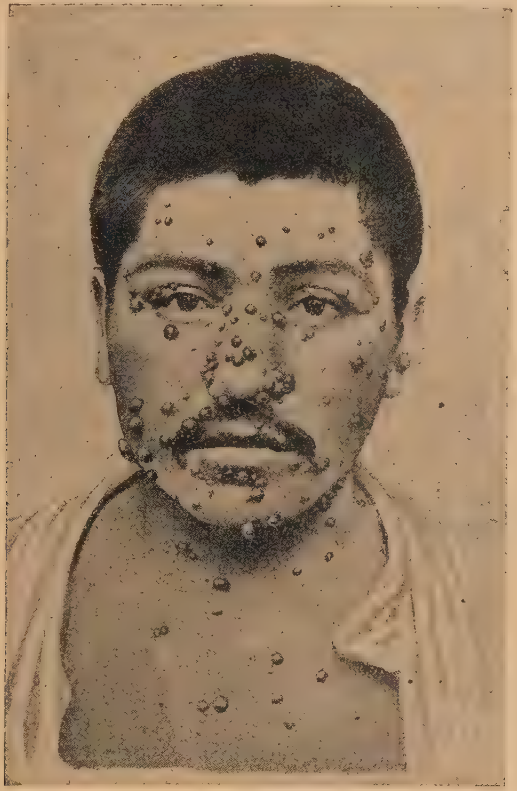

FIG. 53.—Verruca peruviana. The nodular eruption
(From *Practice of Medicine in the Tropics*, Byam and Archibald)

Prognosis The nodular eruption is more chronic than the miliary, and individual lesions may increase to the size of a pigeon's egg, so that they may become a source of danger from haemorrhage. The nodules in this type recur in crops and the duration may extend over two or three months. The mortality from verruca is practically nil.

Diagnosis The appearances of verruca are so characteristic that it is not likely to be mistaken for any other disease. Just conceivably, it may be mistaken for yaws, or simulated by multiple warts, angiomas or molluscum contagiosum.

Treatment Small doses of salvarsan (0·2 gram) or neosalvarsan (0·3 gram), given intravenously and repeated at short intervals, have been tried with success, both in the Oroya fever and in the verruca stage. Kikuth, working on the allied bartonella infection of rats, has produced a new arsenic antimony benzole preparation (386 B) which gives a chemotherapeutic index of 1 : 3500, which is one of the highest chemotherapeutic values known. This has been confirmed by Uhlenhuth (1934). The application of the compound to the treatment of indigenous bartonellosis will be awaited with interest.

When individual verruca tumours begin to ulcerate or become gangrenous, they should be excised.

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BASAL METABOLISM

See METABOLISM, BASAL

BASEDOW'S DISEASE

See GOITRE AND OTHER DISEASES OF THE THYROID GLAND

BATTEN-MAYOU DISEASE

See CEREBRO-RETINAL SYNDROMES

BAZIN'S DISEASE

See SKIN DISEASES: TUBERCULOSIS

BED-SORES

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123.] The development of a bed-sore is usually a reflection on the care and attention bestowed on a patient by the nursing staff and the medical attendants. It is true that in conditions such as myelitis and injury to the cord, which are associated with paraplegia and trophic disturbances, bed-sores develop and extend in spite of every possible prophylactic and therapeutic measure; but fortunately these unavoidable cases form a very small minority.

Aetiology

Excluding cases associated with disease of the spinal cord, four factors dispose to the formation of bed-sores—pressure, injury, maceration and malnutrition of the skin.

Pressure

Prolonged pressure may affect especially the heels, sacrum, posterior superior iliac spines, scapulae and elbows. It has been proved experimentally by Trumble that a pressure of more than 1·5 pounds to the square inch over a prolonged period is likely to cause necrosis of the skin, even if this was previously quite healthy. He also pointed out that the surface area of a man whose height is 5 feet 8 inches and weight 150 pounds, is about 2,790 square inches. If only one-fifth of this surface is available for weight-bearing in the recumbent position the pressure, if evenly distributed, would be less than a third of a pound to the square inch; and such slight pressure would assist the nutrition of the part by supporting the tissues. In practice, however, the weight is chiefly borne by certain local areas, the combined surface of which is small. The practical application of these facts is that as far as possible the whole of the surface must be made to share in weight-bearing, and special attention must be devoted to the protection of bony prominences.

Frequent change of posture and redistribution of pressures are the two methods available for the prevention of excessive pressures over localized areas; of these, change of posture is probably the more important. Normally, a healthy person changes his posture at frequent intervals, especially if resting on a hard surface, and the nursing of a patient for an occasional hour or so on alternate sides is a great help in the prevention of bed-sores of the back. If lying on the side is permissible, then the skin over the great trochanter must receive zealous attention.

Redistribution of pressure can be obtained in various ways. The water-bed, formerly very popular, is valuable in cases likely to need prolonged nursing. It should be partially filled with water at 95° F. so that pressure with both hands and arms just fails to reach the underlying surface. Air-cushions are useful in some cases, especially for protection of the heels, and in this connexion a pillow under the knees will support the leg in comfort and allow pressure to be borne by the under surface of the heel, rather than by the more vulnerable posterior portion. Cotton-wool rings, or rings fashioned from a sheet of sorbo rubber, are useful in preventing pressure on the bony prominences of the back. From the point of view of both prophylaxis and comfort, the presence of normal lumbar lordosis should be taken into account. A soft pillow, or an adequately inflated air-cushion, inserted under the hollow of the back, allows a large area of skin to share in the burden of pressure bearing, and the consequent support afforded to the lumbar muscles and ligaments prevents stretching and the resulting weakness, which is so often a source of complaint by the patient who has been confined to bed for weeks or months.

Injuries

Injuries, unless previously inflicted, are always preventable. They are most commonly due to ill-adjusted supports or wrinkling of the underlying sheets or clothing of the patient. Keeping the draw-sheet tight and smooth is an elementary duty for the nurses. Even a biscuit crumb, if overlaid for a few hours, may cause a small abrasion which subsequently becomes a bed-sore. Furthermore, some laundries return sheets in a hard and unyielding condition, and sometimes impregnated with irritating chemicals. It is the duty of those in charge of the patient to ascertain that sheets are soft, pliable and non-irritating.

Maceration of the skin

Maceration of the skin is especially liable to occur in spinal cases complicated by incontinence of urine or faeces. Fortunately most cases of paraplegia are constipated, and an occasional enema can be carefully given with adequate results. Incontinence of urine in the male is dealt with by keeping a urinal in position. In the female, or in cases complicated by discharging wounds, the arrangement of absorbent material and mackintoshes should prevent maceration of adjacent skin. Excessive sweating must be treated by frequent sponging and local applications.

Malnutrition of the skin

Malnutrition of the skin is combated by assiduous attention to the back and heels. At least once a day, and more often if possible, subject to the general condition of the patient, he is turned so as to face the nurse, and the back is sponged, dried, massaged and powdered. The massage should be in the form of gentle kneading, combined with effleurage, and at the same time some astringent and stimulating preparation is rubbed into the skin. Most nurses have their favourite medicament, which may be eau-de-Cologne, brandy or varying strengths of alcohol. It should be emphasized that surgical spirit must be used, and not methylated spirit, as the latter contains irritating substances which are liable to blister the skin. Following the application of the astringent, the skin is dusted with talcum powder, bismuth subgallate, or some preparation such as equal parts of zinc oxide, boric acid and starch. Careful preparation of the powder is essential as small pieces of grit will cause an excoriation which is a possible loophole for infection.

Clinical development in three stages

A bed-sore develops in three stages—threatened bed-sore, inevitable bed-sore and ulcer—of which the last is apt to be associated with extensive necrosis of fasciae, muscles, ligaments and bone. Fortunately, even when the tissues are extensively destroyed, the patient is usually unaware of the true condition.

Treatment in stage 1

Threatened bed-sore is indicated by redness of the skin, which disappears on gentle pressure. If the skin is soft and pliable, it should be hardened by the application of 5 per cent solution of silver nitrate in distilled water, or by the application, several times daily, of alum solution. Fantus recommends the following prescription:

Alum – – –	30 grams
Water – – –	250 c.c.
Alcohol – – –	250 c.c.

Dissolve the alum in the water and add the alcohol.

If the skin is dry and hard, as over the heels, some protection can be given by several coatings of collodion, or strips of elastoplast. The latter must be carefully applied without stretching, and wrinkles or overlapping edges must be avoided.

Treatment in stage 2

Inevitable bed-sores are diagnosed by the presence of redness and congestion, the appearance of which is unaffected by pressure. Treatment in these cases is directed to minimizing the amount of tissue destruction, but even if pressure is completely removed some degree of necrosis is to be expected. Many therapeutic remedies have been advocated for the impending bed-sores, including ointment of scarlet red B.P.C. (scarlet red 5 parts with 35 parts of simple ointment) and ultra-violet rays, but possibly the most efficient is tannic acid.

Tannic acid is used as for burns (see p. 724). A freshly prepared 5 per cent aqueous solution is sprayed on hourly, and between applications the affected surface is exposed to dry heat from electric lights suspended from a cradle. If available, an electric hair-drier is more efficient. About twenty-four applications are necessary before an adequate coagulum has formed. No further dressing is required or desirable, and as the coagulum separates the edges are snipped away. As a rule healing progresses in the same satisfactory manner as in burns. If, on account of underlying infection, it is necessary to remove the coagulum, it can be softened by the application of a gauze pad soaked in liquid paraffin.

Treatment in stage 3

Ulceration, the final and dreaded stage of bed-sores, presents an anxious problem to the medical and nursing attendants. Treatment is either protective, by the application of tannic acid or elastoplast, or, if this fails or is inadvisable, antiseptics and stimulants are applied. Greasy preparations, such as cod-liver oil or castor oil, are not recommended in the treatment of active ulcers.

Tannic acid should be used only when infection and extension have been controlled, otherwise underlying suppuration necessitates frequent removal of the coagulum to allow the escape of pus. The application of elastoplast is recommended and should always be given a trial. Carty has reported a series of cases in which he obtained excellent results. Two pieces of elastoplast, one over the other, are applied so that the bed-sore and surrounding skin are covered. The plaster is left in position until it becomes loosened by underlying pus, which occurs in from twelve to forty-eight hours. It is then removed and the base of the ulcer is cleaned with cotton-wool before the re-application of the plaster. The elastoplast protects the granulations from injury, and possibly the retained discharge exerts some proteolytic influence which liquefies and assists in the removal of necrosed tissue. The elastoplast method of treatment is simple and usually effective, and requires no skilled nursing or constant attention. If the ulcer becomes indolent, an occasional wash with warm soap and water, followed by the application of red lotion B.P.C., sometimes expedites healing.

In a few cases, especially if a spinal lesion is present, protective measures fail, and the ulcer, with associated inflammation, continues to extend. This is the only stage of a bed-sore in which moist applications are permissible. Mild antiseptics, such as eusol, flavine, dettol or mercurial preparations, must then be applied. Eusol is very efficient, but nurses are apt to warm it, thus destroying its virtue by driving off the chlorine. A frequent change of antiseptic is advisable, as with all infective wounds. When the discharge lessens, a 10 per cent mixture of ichthyol with glycerin is a valuable application, and one which I have used with encouraging results. When extension of the sores has been checked and infection has subsided, protective measures, such as the tannic acid spray or elastoplast, should be instituted. At a later stage, when the discharge is merely serous and healing has started, a stimulating preparation, such as equal parts of zinc oxide and resin ointment or red lotion, will often encourage growth of epethelium and so shorten the time required for healing.

Plaster sores

The present popularity of plaster of Paris in the treatment of recent fractures of the limbs and spine has resulted in an increasing incidence of plaster sores. Prophylactic measures consist in adequate protection of bony prominences, and the avoidance of movement of a limb after the application of a plaster. Any flexion or other alteration in the position of the limb while the plaster is still soft causes ruckling of the plaster, and the resultant ridges are liable to cause pressure sores. These sores are painful for perhaps only twenty-four hours, after which necrosis of tissue progresses painlessly. Should this occur, palpation of the plaster reveals a rise in temperature which is readily appreciated by a discerning hand. If this warning is neglected, a discharge of pus occurs under the plaster a few days later; needless to say, however, the plaster should be removed as soon as the condition is suspected, and the sore treated on the principles enunciated above.

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BELL'S PARALYSIS

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Reference may also be made to the following titles:

CRANIAL NERVE AFFECTIONS
EAR DISEASES

1.–DEFINITION

124.] The name Bell's paralysis is given to that common form of unilateral paralysis of the facial muscles which occurs as an isolated nervous lesion without any definite aetiological factor except exposure to cold.

2.–AETIOLOGY

Nerve sheath inflammation

Although most common in early adult life, it may occur at any age and the sexes are equally affected. It is probably the result of an acute inflammation of the sheath of the seventh nerve, an interstitial neuritis, but the exact point at which the nerve is attacked is uncertain. Sometimes it is in the stylomastoid foramen, sometimes further back in the Fallopian aqueduct, and sometimes perhaps more peripherally in the deep part of the parotid gland. In the majority of cases no causal factor can be found except the local effect of cold, such as a draught from a window; occasionally it may be associated with infections of the nasopharynx or the mouth.

3.—CLINICAL PICTURE

Onset

The onset of the paralysis is rapid and often sudden; the patient may wake in the morning to find one side of the face completely paralysed. There is no pyrexia. In many cases pain is present at the onset and may last for a day or two; it is seldom, however, severe and is felt at the angle of the jaw or in the ear. Tenderness can often be elicited on firm pressure in the region of the stylomastoid foramen or just behind the ramus of the jaw. There is no pain in the face, although the patient may notice a curious feeling of stiffness in it.

Facies

The condition is generally easily recognized. The affected side of the face is motionless and devoid of expression; the naso-labial furrow is either flattened or completely obliterated and the mouth may be drawn to the sound side; the eye on the paralysed side appears more widely open than normal, and tears may run down the cheeks (epiphora). The cheek may be puffed out in breathing, as a result of paralysis of the buccinator muscle, and food may collect between the teeth and the cheek. If the mouth be much drawn over to the sound side, a false appearance of deviation of the protruded tongue may be produced.

Loss of eyelid control

It is impossible for the patient to close the eye tightly on the paralysed side; the eyeball rolls upwards so that the cornea tends to disappear underneath the upper lid. The inability to shut the eye allows the easy entrance of foreign bodies, hence there is an unusual liability to conjunctivitis, a danger which is further enhanced by the loss of the normal corneal reflex from the abolition of the power of closing the lids. The furrows of the forehead are smoothed out and the patient is unable to wrinkle his forehead or frown on the affected side.

Movements of lips and cheeks

The paralysis of the lower part of the face abolishes the movements of the lips and cheek on the affected side, so that in smiling the normal side only of the mouth moves; furthermore the patient cannot show his teeth on the affected side, neither can he whistle nor puff out the cheeks properly. Occasionally he may inadvertently bite the cheek or lip on the paralysed side. When the paralysis is incomplete, the movements of the upper part of the face, i.e. of the eyelids and forehead, are nearly always less affected than those of the lower part.

Stigmata in severe cases

In all severe cases the reaction of degeneration gradually appears in the paralysed muscles. Loss of taste over the anterior two-thirds of the tongue on the paralysed side is often found, and is due to the spreading of the inflammation above the point of the nerve at which the chorda tympani leaves it. This loss of taste may not occur until some days after the first appearance of the paralysis of the face.

4.—COURSE AND PROGNOSIS

Duration

The duration of the paralysis varies within wide limits. The slightest cases may recover in from two to three weeks or even less; in the more severe, the paralysis may persist for many weeks or months, occasionally even remaining permanently. The absence of actual deformity when the face is at rest is a good prognostic sign, indicating that some degree of tonic contraction of the muscles has remained; often this tonic contraction returns before any voluntary movements of the face are possible.

Response to electrical stimulus

When the paralysis has lasted more than about fourteen days the electrical reactions of the muscles afford a valuable aid in prognosis. If the faradic excitability of the muscles is preserved a good prognosis is always justified, but the appearance of the complete reaction of degeneration indicates that the paralysis will be of considerable duration and that many months may elapse before recovery is complete. The return of voluntary movements is usually fairly rapid after it has begun.

Cases in which loss of taste occurs generally take longer to recover than those in which the nerve is attacked distal to the Fallopian aqueduct.

The prognosis when severe paralysis is a complication of otitis media is generally poor, since in a large number of cases no spontaneous recovery takes place.

Incomplete recovery

When recovery is incomplete a form of contracture of the affected muscles is sometimes seen, appearing in from three to six months after the onset of the paralysis. This contracture is evidenced by a narrowing of the palpebral fissure and a deepening of the naso-labial furrow, with sometimes a slight distortion of the mouth to the affected side. A less common but very distressing sequel is spasmodic contraction of the face or clonic facial spasm, a condition in which intermittent spasm of the facial muscles occurs, resembling the movements produced by faradic stimulation of the nerve.

5.–DIAGNOSIS

In a severe case the diagnosis is easy, but in the slighter cases much care may be needed and a thorough examination must be made to exclude the presence of some more serious disease of the nervous system. In the first place it is essential to decide whether the paralysis is of the upper motor neuron (supra-nuclear) type or of the lower motor neuron (nuclear or infra-nuclear) type.

Supra-nuclear lesions

Supra-nuclear lesions may be distinguished by the following points: (1) the upper part of the face is always less severely paralysed than the lower part, often indeed almost escaping any paralysis, so that the movements of the forehead and the closure of the eye can still be carried out, though perhaps imperfectly; (2) movements which it is impossible to perform by voluntary effort may still be performed involuntarily, e.g. movements in response to emotion, so that the paralysed side of the face may move normally in smiling, laughing or crying; and (3) there is no reaction of degeneration in the affected muscles. Moreover in the majority of cases of supra-nuclear paralysis there is an associated paralysis or weakness of the arm or leg or both, i.e. some form of hemiplegia is present. When the lesion is in the cerebrum, cerebral peduncle or the frontal part of the pons, the face, arm and leg will all be affected on the opposite side of the body to the lesion. If, however, the lesion be in the more caudal part of the pons a crossed hemiplegia is present, the face being paralysed on the same side, and the limbs on the opposite side to the lesion.

Infra-nuclear lesions

Lower motor neuron (nuclear and infra-nuclear) lesions of all kinds are distinguished by the following points: (1) an equal affection of the upper and lower parts of the face (except in very slight cases in which the upper part of the face is generally less completely paralysed); (2) equal paralysis of both voluntary and emotional movements; and (3) the appearance of the reaction of degeneration in the paralysed muscles. A more accurate topographical diagnosis of the lesion in a lower motor neuron paralysis may be made by attention to the following considerations: (1) lesions of the facial nucleus in the pons nearly always present an associated paralysis of the sixth nerve on the same side and often a paralysis of the arm and leg on the opposite side of the body; (2) a lesion of the facial nerve at the base of the brain between its exit from the pons and its entrance into the internal auditory meatus is apt to be associated with affections of other cranial nerves, especially the eighth and fifth, as well as with general cerebral symptoms such as headache and vomiting; (3) a lesion in the Fallopian aqueduct will produce, in addition to the facial paralysis, a loss of taste in the anterior part of the tongue; (4) a lesion confined to the region of the stylomastoid foramen or one more distally placed will not produce any loss of taste.

Significance of bilateral paralysis

Finally it should always be remembered that bilateral Bell's paralysis is so rare that it should never be diagnosed until every other possibility has been carefully excluded. Any bilateral facial weakness must be regarded with grave suspicion as it generally indicates some much more serious condition, such as a basal meningitis, some form of polyneuritis, epidemic encephalitis, myasthenia gravis or some form of muscular dystrophy.

'Geniculate herpes'

A rare form of facial paralysis may be seen in 'geniculate herpes', in which an inflammation of the geniculate ganglion by the virus of herpes zoster occurs. In such cases the herpetic eruption appears on the posterior wall of the external auditory meatus and just behind the ear where the pinna joins the scalp; occasionally herpetic vesicles may be found on the tympanum. Taste, in these cases, is always affected and there is generally some involvement of the eighth nerve with deafness, tinnitus or vestibular disturbances.

A sequel to otitis media

The form of facial paralysis which is found as a complication of otitis media presents the same clinical features as that already described; taste is practically always lost over the anterior part of the tongue. This form of facial paralysis may arise in any severe case of otitis media from an extension of the inflammation to the facial canal, or it may be due to damage to the nerve, or to its actual division during the course of a mastoid operation.

Other rare forms may be the sequel to facial erysipelas. Facial paralysis is a feature of cephalic tetanus.

6.–TREATMENT

Local measures

The immediate treatment of Bell's paralysis should consist in the application of heat to the region of the ear, mastoid process and parotid gland by means of fomentations or poultices. Some benefit is probably produced by blistering and for this purpose a mustard leaf can be placed over the stylomastoid foramen and retained until the skin is reddened.

Drugs

Little effect can be expected from drug treatment but it is perhaps of some value to prescribe a mixture of iodides with salicylates, such as potassium iodide 5 to 10 grains, sodium salicylate 10 grains, compound tincture of gentian 20 minims, water 1 ounce, thrice daily after food.

Electrical treatment

When the acute stage is passed and all pain and tenderness have disappeared, electrical treatment of the paralysed muscles may be started, but it should be clearly understood that this form of treatment is not necessary when voluntary movements of the affected muscles become possible.

Labile galvanism should be used at first, with the negative pole placed over the mastoid and the positive gently stroked over the affected muscles. Weak currents of from 3 to 5 milliamperes should be used. When faradic excitability of the muscles reappears this form of stimulation may also be employed. Electrical treatment should not be employed if any secondary contracture of the muscles has developed, nor should it be continued indefinitely in the absence of evidence of improvement in the paralysis. For it is quite possible that its unduly prolonged application may be a factor in the development of secondary contracture of the paralysed muscles. In cases of severe paralysis in which there is distortion of the mouth steps should be taken to prevent overstretching of the paralysed muscles. This may be effected by fixing one end of a strip of plaster firmly to the angle of the mouth, which is held back into a fully-corrected position by attaching the other end of the plaster to the skin over the angle of the jaw. The same effect may be produced by a simple splint made of wire or malleable metal covered with thin rubber tubing, of which one end can be placed in the corner of the mouth and the other hooked over the ear.

Prevention of distortion

Surgical treatment

If no signs of recovery are apparent after six months' careful treatment, the propriety of some operation of nerve anastomosis may be contemplated. Operation is more likely to be needed in cases due to otitis media than in the ordinary case of Bell's paralysis. Several different operations have been performed. The older operation was to divide the facial nerve behind the angle of the jaw and to insert its peripheral end into the spinal accessory nerve either by lateral implantation or end-to-end. This anastomosis has the drawback that movements of the head and shoulder may be accompanied by movements of the face. A better operation is a partial division of the hypoglossal nerve and the implantation into it of the peripheral end of the facial nerve; this operation, however, produces hemiatrophy of the tongue. A new operation which has recently been practised with success consists in an anastomosis between the peripheral end of the facial nerve and the glosso-pharyngeal nerve. The functional results of this appear better than those obtained by the previous methods of nerve anastomosis.

In 1934 Ballance and Duel published several cases of persistent Bell's paralysis treated by exposure of the nerve in the aqueduct of Fallopius and direct incision of the sheath. The same surgeons recommend that when the facial nerve has been divided or destroyed (usually in association with mastoid disease) the gap should be bridged by a graft obtained from a cutaneous nerve (the lateral femoral cutaneous) which has been divided and allowed to degenerate. Whatever form of operation be employed no return of voluntary power should be expected for at least three months, but after that time some voluntary innervation of the face may be seen and this should gradually increase until about a year after the operation.

When all else fails the persistent deformity may be improved by a plastic manœuvre, the affected muscles being supported by slings of fascia attached to the temporal region above and the region of the angle of the mouth below. In recent years fascial graft operations of this nature have been practised with success, notably by Gillies.

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BENEDIKT'S SYNDROME

See CRANIAL NERVE AFFECTIONS

BERI-BERI

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Reference may also be made to the following titles:

DIETETIC DEFICIENCY DISEASES
DROPSY, EPIDEMIC
NEURITIS
VITAMINS

1.–DEFINITION

125.] Beri-beri is a dietetic disease or group of diseases due to deficiency in vitamin B_1 occurring frequently on board ships, in tropical regions amongst natives living on rice and also in other parts of the world where diet is deficient. It is characterized by a multiple neuritis clinically indistinguishable from neuritis due to other aetiological factors, a myocardial affection sometimes leading to fatal heart failure, and sometimes by extensive subcutaneous oedema and serous effusions. Not all of these components are present in every case.

2.–AETIOLOGY AND PATHOGENY

'White rice'

In 1897 Eijkman in Java observed that fowls fed on decorticated rice developed polyneuritis gallinarum, a beri-beri-like disease, whereas fowls fed on whole rice remained unaffected. In 1907 Braddon, after studying the epidemiology of beri-beri in Malaya, showed that the disease was confined to those who ate 'white rice', and that those who ate 'parboiled rice' escaped. He supposed that some noxious substance was destroyed in the parboiling process.

Vitamin deficiency

Fraser and Stanton, who began their investigations in 1907, first established the view that beri-beri was a deficiency disease. They first studied the epidemiology of the disease in the field, by observing groups of labourers living under controlled conditions as to diet and other factors; then by analysis and experiment in the laboratory they demonstrated that the basic aetiological factor was the absence from the diet of a certain substance, essential though in minute amounts. This substance was one of a group to which Funk later gave the name 'vitamines' (now 'vitamins'). In polishing rice, the pericarp is removed and with it the protein, fat and vitamin B_1; the resulting grain is therefore deficient in these constituents. Natives of the rice-eating populations of India, Japan, China and Malaya, who often live on white rice alone, suffer from deficiency of vitamin B_1 and so are liable to develop the disease.

Although beri-beri is specially prevalent in rice-eating races, rice *per se* is not necessarily a factor in the production of the disease, any food deficient in the antineuritic principle being sufficient to produce it. This explains its incidence in Brazil, where rice is not used, and also in sailing ships; here stale and tinned foods are largely used, and the high temperatures required for sterilizing the latter may destroy the vitamins.

Deficiency of other factors

Diets from which beri-beri develops are usually deficient in other factors as well as vitamin B_1 and some of the clinical manifestations which are included in the beri-beri group may be due to these. Investigations on avian beri-beri, better known perhaps as avian avitaminosis, has helped in the solution of some of the problems met in the human disease. If pigeons are fed on decorticated rice paralysis soon develops, but this, in contradistinction to the paralysis seen in the human subject, can quickly be cured if a diet rich in vitamins is administered.

That simple vitamin deficiency is not the sole operative factor appears from the fact, long known, that fowls or pigeons that are given only water do not develop avian polyneuritis although they outlive the period in which this develops in birds fed on decorticated rice. Further, the clinical and pathological evidence in human beri-beri places this disease in the category of toxic polyneuritis, and it will be remembered that the various poisons—endogenous and exogenous—which give rise to this condition invariably affect the myocardium also. Nevertheless, the discovery of the vitamin-deficiency factor led to the belief that beri-beri is a simple 'vitamin starvation' of the nervous system leading to degeneration of the peripheral nerves.

That such a view was inadequate to explain either the clinical picture or the underlying lesion in the nervous system, that in acute pernicious beri-beri the symptoms and lesion are myocardial and not nervous, and that finally—as has been mentioned—starved birds die without developing avian polyneuritis, were facts for many years overlooked by the biochemical investigators of vitamin-deficiency diseases. A view at once in accord with clinical and pathological considerations and also with the vitamin-deficiency factor is that the consumption of certain diets in the absence or scarcity of the vitamins naturally associated with them allows the development of an endogenous intoxication, the expression of which is a multiple neuritis and a myocardial affection. Recent biochemical investigations are now leading experimental workers to this view, and the probable intervention of such a toxic factor is beginning to be admitted by them.

Geographical distribution

The disease was formerly very prevalent (although it has become much less so since the essential cause was discovered) in India, China, Japan, the Federated Malay States, Sumatra and the other Dutch East Indies, the Philippine Islands, in parts of Brazil, in Newfoundland and Labrador (where white wheaten flour was too exclusively used) and on board steamers coming from the East with Chinese crews (where white rice was largely used) and also on board sailing ships in the Atlantic ('ship beri-beri').

3.–MORBID CHANGES

Peripheral nerve degeneration

It is not yet clear how the absence of the vitamin or antineuritic principle acts; the changes in the nerves are similar to those found in alcoholic and other poisoning. The peripheral nerves show Wallerian degeneration with possibly axonal degeneration of the neuron. The sheath of Schwann may exhibit nuclear multiplication and invasion by leucocytes and undergoes fatty degeneration with gradual absorption. Finally the axis cylinder disappears, the sheath collapses and the nerve disappears in the fibrous connective tissue of the endoneurium. These changes are most severe in the vagus and in the nerves supplying the lower limbs.

Other changes

Characteristic changes are also found in other structures. The veins of the neck are engorged, the right heart is much dilated and distended with blood, and serous effusions are seen in the pleural and pericardial cavities, and the tissues. The cardiac muscle may show oedema and fatty degeneration. The dilatation and subsequent hypertrophy involve especially the right side of the heart. Wenckebach has shown that it is the myocardial lesion, and not an associated vagus neuritis, which is responsible for heart failure when this occurs. In this respect beri-beri resembles other varieties of multiple neuritis in all of which the myocardium is involved. The lungs are much congested and oedematous. The pyloric end of the stomach and the duodenum are congested and reddened and pin-point haemorrhages are not infrequent; the liver may show chronic venous congestion with fatty changes (nutmeg liver), and adrenal hyperplasia has been reported.

4.–CLINICAL PICTURE

(1)—Onset of the Disease

The incubation period appears to be from two to three months, but this naturally depends upon the degree of vitamin deficiency in the diet, and some subjects seem more resistant to such deficiency than others. The onset is usually gradual. In some instances symptoms of gastric irritation, such as epigastric discomfort, nausea and sickness, may usher in the clinical picture; in the so-called acute pernicious form these symptoms may be very severe and, together with acute cardiac dilatation and failure, may end in death within a few days without any symptoms referable to the nervous system.

Vervous ymptoms

But in the commoner and less acute forms the mode of onset is that characteristic of multiple neuritis, namely, numbness and tingling in the extremities—particularly in the feet and toes, aching and cramps in the calf and plantar muscles, progressive weakness of the legs most marked in the dorsiflexor muscles and leading to foot-drop and steppage gait.

There is impairment of all forms of sensation in the lower extremities, and in severe cases also in the hands and forearms. The weakness may progress to severe disablement; it may be followed by the appearance of muscular wasting in the legs and in long-standing cases by contracture and deformity. The sphincters are not affected and the cranial nerves commonly escape.

Heart ymptoms

These signs and symptoms are accompanied by tachycardia, and in severe cases by cardiac dilatation.

Fever

The disease runs an afebrile course, although there may be slight initial fever.

(2)—Classification of Types

The common classification into clinical types is largely arbitrary and does not always represent essential or qualitative differences, but the following subdivision has a certain practical usefulness.

(*a*) *Larval or Ambulatory Type*

This may be taken to represent the reaction to partial deficiency of the vitamin.

The signs and symptoms are those of a low-grade multiple neuritis: tingling and numbness of the feet and toes with some local impairment of sensation, tenderness of the plantar and calf muscles, diminution or absence of the ankle-jerks, and in more severe cases of the knee-jerks also—though the latter are always affected later than the ankle-jerks; it is therefore important to examine the condition of the ankle-jerks as well as that of the knee-jerks. These signs clear up in a few weeks if the patient be placed upon a more balanced diet in which vitamin B_1 is adequately represented. It might be more correct to say that such cases are an early stage of a more severe affection than that they are a special type, and if they are not promptly treated they will develop into severely paralysed cases. Their recognition is therefore of great importance. *Nervous symptoms*

(*b*) *Ordinary Beri-beri*

The onset is indicated by paraesthesiae in the lower extremities, aching and cramps in the leg muscles, progressive weakness of the legs as already described, loss of ankle- and knee-jerks, impairment of all forms of sensation, most profound in the extremities and lessening gradually towards the base of the limb. There is foot-drop, and unsteadiness of gait from impairment of postural sensation in the legs with Rombergism. Finally the patient is bedridden and muscular wasting appears. The arms are affected much later and much less severely than the legs, but they also may become very weak and wasted especially in the distal parts, and the arm-jerks may disappear. As in alcoholic neuritis, the feet and legs may for a time become very painful and hyperaesthetic. The sphincters are not affected.

In what is called 'dry beri-beri' this multiple neuritis and the associated myocardial involvement (tachycardia and cardiac dilatation) together complete the clinical picture, but in 'wet beri-beri' there is also marked oedema of the feet and lower part of the legs, sometimes of the scrotum and abdominal wall and lower part of the back. Serous effusions may also develop and the patient become water-logged. *Oedema*

In cases which end fatally, the cardiac disturbance becomes severe—although it is doubtful whether vagus neuritis plays any essential part in this disturbance. There is dilatation of the right heart, congestion and pulsation of the veins in the neck. Systolic murmurs are present on auscultation and a peculiar spacing of the first and second sounds which is due to equalization of the short and long pauses. The second sound may be reduplicated or accentuated. The pulse is rapid and of low tension. The urine presents no abnormalities. *Cardiac symptoms*

When such a patient recovers, the oedema clears up and then the muscular wasting of the extremities and a severe multiple neuritis are revealed.

(*c*) *Acute Pernicious or Cardiac Form*

As described by Hamilton Wright, this form begins acutely with signs of gastro-duodenal irritation, epigastric pain and sickness and signs of cardiac failure. The latter have been described above and they terminate in death sometimes within forty-eight hours of onset. Serous effusion and subcutaneous oedema may develop. To what degree such cases are directly due to sudden deprivation of vitamin B_1 or indirectly to an intoxication resulting therefrom is not certainly known, but it is probable that the latter factor is the essential one.

(*d*) *Infantile Beri-beri*

This form of beri-beri is found in Japan, the Philippine Islands and other islands of the Pacific. It attacks breast-fed infants whose mothers are suffering from vitamin deficiency, whether with or without clinical symptoms. The death-rate is high and in the acute form of the disease death occurs quickly, the infants developing cyanosis, dyspnoea and muscular rigidity. There are no signs or symptoms referable to the nervous system and in this respect infantile beri-beri resembles the acute pernicious form. In the chronic forms vomiting and diarrhoea occur, and anaemia and oedema with paresis of the limbs follow.

Course and symptoms

Infantile beri-beri should be treated by substituting artificial for breast feeding, and extract of rice polishings and other foods containing vitamins should be administered.

Treatment

(*e*) *Ship Beri-beri*

This occurs in two forms: (*a*) ordinary beri-beri which occurs in Chinese crews fed on white rice, and (*b*) the form seen amongst white sailors on sailing ships in the Atlantic whose diet, though not consisting of rice, is deficient in vitamins, especially B_1. As a rule these patients show the dry form, with paralysis of the lower limbs as the chief symptom.

(*f*) *Epidemic Dropsy*

Aetiology

Authorities are not generally agreed whether this is a disease *sui generis* or whether it should be placed with beri-beri. As there are no very definite points of distinction between the two, it may best be considered as a variety of the latter. Megaw has shown that epidemic dropsy in India is caused by the consumption of rice that has been stored under damp conditions, quite irrespective of its vitamin content, usually undermilled parboiled rice which has undergone changes during storage in the damp hot rainy season. As prompt recovery follows the substitution of a rice-free diet in the early stages of the disease, the symptoms are probably due to a toxin developing in the defective rice. The disease is thus an easily preventable one, for it is scarcely ever seen in those who keep their rice dry in the form of paddy with the protective covering intact, and prepare it freshly for use in small quantities at a time.

The disease occurs in Calcutta and other parts of India and is seen from time to time in London amongst Lascar crews on board the steamers coming to the docks. Both sexes are liable to the disease, children less than adults.

Symptoms

There is usually fever in the initial stages, and later dropsy, which may spread all over the body: this is followed by paresis and paralysis in the legs: the knee-jerks may remain. Diarrhoea and vomiting are common, also pain and aching in the muscles and joints; an erythematous rash may appear on the extremities usually after the oedema has disappeared, and last for some twelve days. The cardiac disturbances are similar to those met in ordinary beri-beri. The treatment of epidemic dropsy is similar to that of ordinary beri-beri. A more generous diet should at once be instituted, and should contain plenty of vitamin B_1; lemon-juice should also be added to provide vitamin C as there is sometimes a scorbutic element present in such cases. If the heart shows signs of involvement, cardiac tonics may also be required. (Epidemic dropsy is discussed from another point of view in the article under that title.)

Treatment

5.–PROGNOSIS

The prognosis must necessarily depend on the amount of care and attention that can be given. During an epidemic among natives it may be impossible to provide sufficient hospital treatment, and so the death-rate rises. Patients admitted to hospital usually recover if the first two days are passed successfully, but even then a cautious prognosis is necessary as cardiac failure is apt to appear suddenly even when the patient is doing well. Severe vomiting is a bad sign and was always recognized by the Japanese as of grave significance.

6.–DIAGNOSIS

Diagnosis is not as a rule difficult, but whenever multiple neuritis occurs in epidemic form the possibility that beri-beri may be in question has to be considered. Thus, of the Dublin and Manchester epidemics, the former was never explained, and the latter proved to be arsenical neuritis due to the pollution of beer by glucose containing arsenic.

Differentia diagnosis

In the Palestine campaign in 1917 an outbreak of multiple neuritis among troops proved to be due to unrecognized cutaneous and wound diphtheria, whereas a similar outbreak in Mesopotamia was probably due to dietary deficiency and was thus true beri-beri.

In the case of beri-beri without oedema ('dry beri-beri') the condition must be differentiated from multiple neuritis due to other causes, but in 'wet beri-beri' the cardiac symptoms and the oedema may mask the nervous manifestations, and in these circumstances differentiation must be made from cardiac and renal disease and from ankylostomiasis. A careful history and the examination of the nervous system for signs of multiple neuritis are of importance.

7.–TREATMENT

(1)—Prophylaxis

Diet

As a result of the discovery that beri-beri was due to a deficiency in diet—a vitamin deficiency—great progress has taken place in its prevention. The disease has largely been stamped out in the jails and government institutions in the Federated Malay States and on board steamers trading with the East, simply by changing the diet and giving parboiled or cured rice (i.e. rice that has been boiled and dried before husking) instead of a highly polished one.

In cases showing any premonitory symptoms of the disease, such as pains or heaviness in the muscles of the legs, vitamins should at once be administered.

(2)—Curative Treatment

In the treatment of a case of beri-beri, each of the various components of the disease must be considered. These are the dietary deficiency, the multiple neuritis and the myocardial affection. In every case complete rest in bed is the first essential, and the patient should not be allowed up until the pulse-rate has fallen to normal and the multiple neuritis is manifestly clearing up.

Diet

Dietary treatment. In severe cases small and frequent feeds should be given, consisting of eggs, milk, heart muscle, liver, and orange-juice. Yeast in some form should also be given—either as marmite ($\frac{1}{2}$ to 2 ounces daily) or as baker's yeast ($\frac{1}{2}$ to 1 ounce daily) eaten whole or broken up and suspended in water. Alternatively, vitamin B_1 may be given in concentrated form—e.g. an adsorbate of the vitamin on Fuller's earth. Preparations with a declared potency, expressed in international units, should be preferred, and in severe cases should be given in doses of 2,000 to 4,000 units daily. Later a dry, low carbohydrate diet rich in vitamins should be given together with yeast. It is probable that vitamin A should also be given in some form.

Physical treatment

Treatment of the multiple neuritis. The patient, even in mild cases, should be kept in bed until improvement sets in. In severely paralysed cases the foot should be kept at right angles to the leg by splint or sandbag, and the legs very slightly flexed at the knees by a small pillow; they should not be allowed to rotate outwards. If there be wrist-drop this may call for similar measures. If the muscles are very painful or tender, massage should be of the gentlest and accompanied by restricted passive movements. It is extremely doubtful if electrical stimulation of the muscles is of value at any stage, but if employed it should be reserved for the later stages when pain has abated and it should be confined to the weakest muscles, i.e. the dorsiflexors of the foot and the extensors of the wrist and digits. The galvanic current should be preferred. When recovery is setting in, active and passive movements and massage are of value.

In multiple neuritis, whether it be mild or severe, recovery is slow and usually many months ensue before power is restored to normal. The return of the lost tendon-jerks is even longer delayed. Active movements undertaken while the patient is still in bed must precede walking exercise, and the latter must be carefully graded.

Comparison with avian polyneuritis

In view of the rapid recovery seen in experimentally produced avian polyneuritis, the slow recovery of the human subject from beri-beri may appear remarkable. But it must be borne in mind that the two maladies are not strictly comparable in all respects. In birds polyneuritis is produced by giving pure carbohydrate in the complete absence of vitamin. The weakness of movement thus rapidly produced is due to a loss of conduction in nerve fibres which have not yet undergone degeneration, and which are thus readily restored to normal function when vitamins are administered. In man the vitamin deprivation is usually relative, and nerve-fibre degeneration has had time to take place during the long incubation period before adequate treatment is begun. It is clear that from such a degenerative process recovery must necessarily be slow.

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BERNHARDT'S MERALGIA

See BACKACHE AND LUMBAGO, p. 258; *and* NEURITIS

BESNIER'S PRURIGO

See ALLERGY, Vol. I, p. 327

BILE-DUCTS

See GALL-BLADDER AND BILE-DUCTS

BILHARZIASIS

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I.—VESICAL BILHARZIASIS

1.–DEFINITION

126.] Vesical bilharziasis is a chronic disease, caused by *Schistosoma haematobium*. It is characterized by terminal haematuria, cystitis and the passing of terminal-spined ova in the urine.

2.–PARASITOLOGY

The Schistosomidae

Man is commonly the definitive host of several species of blood flukes of the family Schistosomidae, first described by Bilharz in Cairo in 1851. The adult worms inhabit the portal system and its tributaries and deposit their ova in the walls of certain hollow viscera, mainly the bladder or large intestine, whence they reach the exterior in the urine and faeces. Vesical bilharziasis, caused by *Schistosoma haematobium*, is characterized clinically by terminal haematuria, while the intestinal types caused by *S. mansoni* and *S. japonicum* produce dysenteric symptoms with diarrhoea, and blood and mucus in the stools. Fischer has recently described a new schistosome in the Belgian Congo, *S. intercalatum*, which deposits terminal-spined ova, resembling those of *S. haematobium*, in the human intestine, but not in the bladder. Man may occasionally be infected by certain animal species such as *S. bovis* and *S. mattheei*.

The intermediate hosts

Miyairi and Suzuki in Japan, and Leiper in Egypt, found that the intermediary host is a fresh-water snail; this becomes invaded by freely-swimming miracidia liberated from bilharzia ova on contact with water. The intermediary hosts vary in different countries, being *Bulinus contortus* in Egypt, *Physopsis africana* in Natal and *Planorbis metidjensis* in Portugal. In the liver of the mollusc the miracidia develop into sporocysts which produce cercariae; in four to five weeks, when mature, these freely-swimming cercariae gain their freedom and within twenty-four to forty-eight hours must find a suitable host, perhaps among bathers, or die: they penetrate the skin and subsequently proceed, via the veins, into the portal system of man where they develop into adult schistosomes in six to seven weeks.

Schistosoma haematobium

Schistosoma haematobium, the causal organism of vesical bilharziasis, appears to have originated in the Nile valley where it has been endemic for thousands of years. Eggs were found by Ruffer in the renal pelvis of a mummy of the 20th Dynasty (1250–1000 B.C.). The adult female is enfolded in the gynaecophoric canal of the male worm. The ova have a sharp terminal spine and measure 120–160 by 40–60 microns.

Geographical distribution

From the Nile valley the disease has spread to most parts of Africa as well as to Palestine, Arabia, Iraq, Madagascar, Cyprus, Portugal and elsewhere.

3.–MORBID ANATOMY

Though a few schistosomes may be found in the mesenteric vein and its branches, their chief habitat is the vesical, and prostatic or uterine plexuses of veins; and ova are deposited in the bladder, prostate, seminal vesicles, urethra, cervix and vagina. These plexuses drain into the inferior vena cava and thus stray ova filter out into the lungs. Pulmonary fibrosis associated with egg deposits may occur. Vesical lesions include bilharzial pseudo-tubercles, papillomas, ulcers and chronic fibrosis of the bladder wall. In addition there may be involvement of the lower third of the ureter, chronic fibrosis of the prostate and seminal vesicles, bilharzial infiltration of the penis and peri-urethral tissues with the formation of sinuses. Terminal-spined ova are less frequent in the intestine and liver in vesical bilharziasis than in other schistosome infestations, in which the parasites inhabit the portal system proper. The appendix, however, may show fibrosis and subperitoneal nodules associated with deposits of ova.

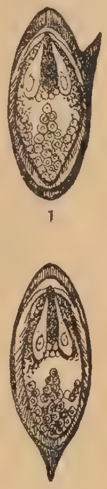


FIG. 54

(1) Lateral-spined ovum of *S. mansoni* (intestinal bilharziasis)
(2) Terminal-spined ovum of *S. haematobium* (vesical bilharziasis)
(*Parasitology*, 1920)

Apart from suctional trauma and the general and local effects produced by the excretions and secretions of schistosomes in the portal system, egg deposits at an early stage cause considerable inflammatory reaction in the tissues resulting in the formation of small submucous or subperitoneal nodules or pseudo-tubercles, composed of giant cells, round cells, and generally eosinophil polymorphonuclear leucocytes; later these nodules disappear and are replaced by whorls of fibrous tissue in which degenerated and calcified eggs are found. Papillomas may also appear in the bladder and ureter; these result from proliferation of epithelium irritated by the toxic secretions from the worms and ova, and also from elevation of the mucosa by submucous cellular accumulation.

4.–CLINICAL PICTURE

Initial symptoms

A cercarial dermatitis may be produced when the cercariae first penetrate the host's skin.

A syndrome characterized by headache, rigors, fever, generalized body pains, urticaria and eosinophilia may appear between the fourth and the twelfth week of the disease, but is generally less evident than with *S. mansoni* and *S. japonicum* infestations.

The early symptoms

Localizing vesical symptoms generally appear within three to nine months, but may be delayed for years. The earliest symptom is burning urethral pain on micturition (60 per cent) followed later by terminal haematuria; urgency, frequency of micturition, perineal pain, and aching in the loins may also be noted early. The haematuria is essentially terminal in type; it may occur more or less constantly or may appear during periods lasting a few days separated by clear intervals of several months. The blood is bright red in colour, although occasionally dark worm-like clots may be passed; the haematuria is aggravated by violent exercise, especially horse-riding.

Pain

Pain is not a dominating clinical feature but may be urethral, perineal, supra-pubic or renal in distribution. Backache and pain referred to the iliac fossae are not uncommon, and pressure on the bladder may elicit pain referred to the tip of the penis.

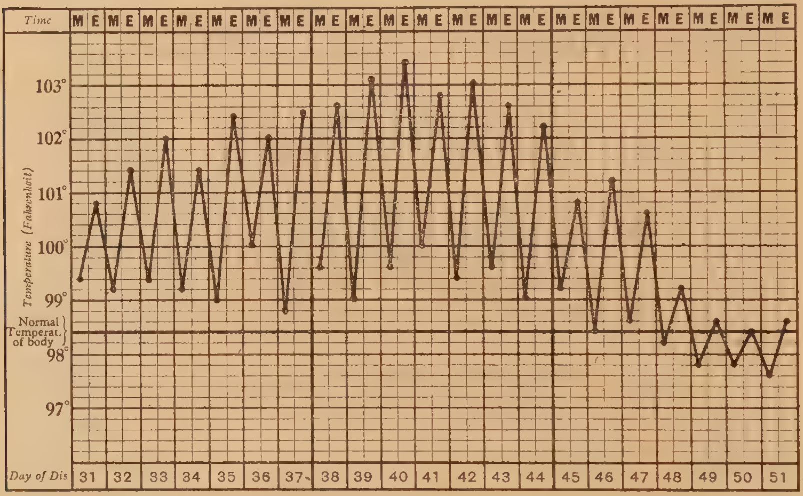


FIG. 55.—Temperature chart in a double infestation with *S. mansoni* and *S. haematobium* beginning 31 days after bathing in an infected pool. Remittent temperature with an evening rise was a characteristic feature. Ova were not demonstrated until after the fever had subsided

Genito-urinary and rectal symptoms

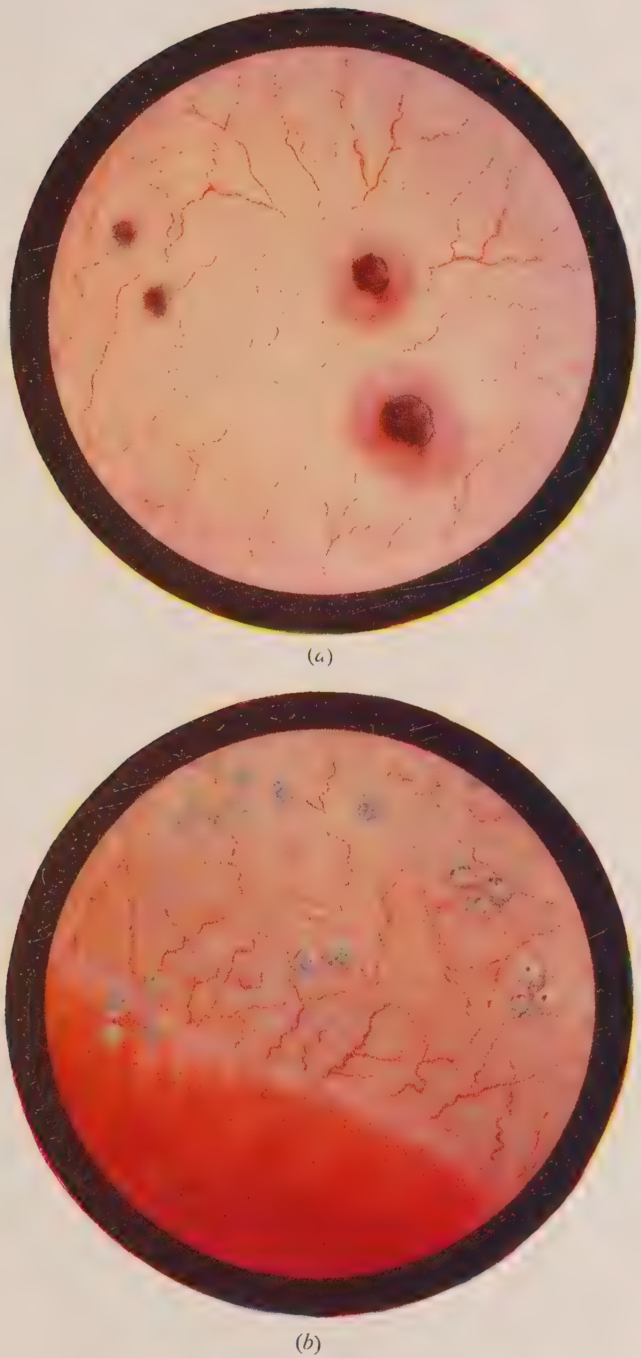
When the prostate and seminal vesicles are involved haemospermia (blood-stained nocturnal emissions) may result and ova may be demonstrated in the semen although absent from the urine. Rectal symptoms are uncommon, but blood and mucus containing terminal-spined ova may occasionally be passed per rectum. The late clinical stages of vesical bilharziasis include various complications which will be referred to later.

Physical stigmata

Examination may at first reveal little abnormal, although sometimes supra-pubic tenderness is elicited on palpation and tenderness of the prostate and seminal vesicles on rectal examination.

Cystoscopy

The earliest cystoscopic signs (see Plate II) are yellowish submucous nodules involving especially the base of the bladder; as the ova die



Cystoscopic appearances in vesical bilharziasis

(*a*) Injection of vessels and ulceration.

(*b*) Pseudo-tubercles due to *Bilharzia*. These yellowish, submucous nodules are commonly encountered during the first year of the disease.

[From the Author's contribution to Taylor's *Practice of Medicine* (15th ed. by E. P. Poulton, 1936)]

PLATE II

[*To face p.* 326

these nodules assume a creamy white colour. Ulcers, papillomas and sandy patches may appear later, the last being characterized by a bright yellow light reflex due to the presence of calcified ova. Ureteric involvement, calculi and carcinoma may also be evident. X-ray examination after uroselectan may reveal polypi, calculi, dilated ureters and hydronephrosis.

X-ray findings

5.–COURSE AND PROGNOSIS

The disease, if untreated, runs a very chronic course but spontaneous recovery sometimes ensues. If repeated infections have occurred, fatal complications, such as uraemia, urinary sepsis and carcinoma may supervene. This, however, may occur apart from repeated infection; one of the author's patients, who acquired the disease thirty years previously in South Africa and had not since been exposed to infection, died of vesical carcinoma and at autopsy living schistosomes were found. In the absence of serious complications vesical bilharziasis is curable by modern therapy.

Complications

Bilharzial stricture of the ureter, or blockage due to papillomas, may lead to chronic nephritis or hydronephrosis, and secondary bacterial infection may result in septic cystitis, ascending pyelonephritis, or pyonephrosis. Calculi and vesical carcinoma are frequent; peri-urethral abscess, fistulae and carcinoma of the penis may develop, and in women bilharzial involvement of the labia, vagina, cervix, uterus and even Fallopian tubes may be found. Chronic fibrosis of the appendix and whitish, subperitoneal nodules, often mistaken for tuberculosis, may result from local deposits of ova in vesical as well as in intestinal bilharziasis.

6.–DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

In the early toxic or anaphylactoid stage the diagnosis is suggested by the intense eosinophilia and history of exposure to infection; it is confirmed by the intradermal skin test and the complement-fixation reaction, using as antigen the cercarial extracts devised by Fairley.

Complement-fixation reaction

The complement-fixation reaction is the most reliable means of diagnosis during the invasive stage before ova appear in the excreta, and the serum almost invariably reacts positively when an alcoholic extract of liver infested with bilharzia cercariae is used as antigen. The reaction persists in many cases throughout the whole course of the disease, but its intensity tends to decrease and the percentage of positive reactions is lower in the more chronic cases. The reaction is of group nature and does not differentiate the species of infesting schistosome. The deposit obtained by centrifugation of the last few c.c. of urine should be examined, and investigations of several different specimens are sometimes necessary before ova are demonstrated; occasionally ova are found in the sputum and faeces. In doubtful cases the diagnosis should always be confirmed by cystoscopy and the complement-fixation reaction.

Blood counts

An intense eosinophil leucocytosis associated with urticaria characterizes the early invasive stages, the total leucocytes being 15,000 to 25,000 per c.mm., of which 20 to 60 per cent are eosinophils. During the next year or two the counts fall and a moderate eosinophilia of 5 to 20 per cent is the rule, and in the chronic stages the eosinophilia practically disappears; with the onset of sepsis a neutrophil leucocytosis develops. A secondary anaemia of moderate degree supervenes in some cases.

Differential diagnosis

When localizing symptoms appear, vesical bilharziasis may be confused with acute nephritis, renal and vesical calculus, papillomas of the bladder, tuberculous ulceration and other causes of haematuria.

When the blood is equally distributed throughout the whole act of micturition the presence of papillomas or carcinoma should be suspected.

7.–TREATMENT

Prevention

Prophylaxis consists in preventing excretal contamination of water, in destruction of the snail vector, in avoiding drinking, swimming or washing in infected water, and in eradicating the disease in man by specific drug therapy.

Specific Treatment

Several drugs, including emetine and such trivalent antimony compounds as tartar emetic and fouadin, exert a specific lethal action on schistosomes in both man and animals.

Tartar emetic

Tartar emetic (potassium antimonyltartrate) was first successfully used by Christopherson: it is given intravenously every second day in 10 c.c. of isotonic saline or 5 per cent glucose solution, commencing with ½ grain and increasing by ½ grain until a maximum of 2 grains is attained. The total course for the adult is 30 grains; the solution must be fresh, and sterilized on the same day as used. A short bevelled needle should be used and great care be taken that no solution escapes into the tissues, otherwise acute inflammation and sloughing result. Spasmodic cough often appears within a minute of the injection and toxic muscular pains may develop later in the course; the tendency to vomiting may be minimized by giving the injection on an empty stomach or three to four hours after a light meal. The drug is generally well tolerated except in cases complicated by heart failure, hepatic cirrhosis, renal involvement, sepsis or fever. The development of persistent vomiting, diarrhoea, rapid pulse and jaundice are indications to stop treatment. Tartar emetic first depresses the reproductive power of the schistosomes and later kills them, and viable ova rapidly disappear from the excreta; it may also exert a direct lethal action on the miracidia.

Sodium antimonyltartrate B.P. is more soluble and is stated to be less toxic than the potassium salt. It is given in the same doses as the potassium salt and by the same technique.

Fouadin

Fouadin or neo-antimosan (sodium antimony-pyrocatechin-disulphonate) is supplied in the form of a 6·3 per cent sterile isotonic solution, the total course consisting of 40 c.c. given in nine injections (1st day, 1·5 c.c.; 2nd day, 3·5 c.c.; 3rd, 5th, 7th, 9th, 11th, 13th, and 15th days, 5 c.c.). The injections are painless and are given intramuscularly into the buttock; an all-glass syringe with platinum or rustless steel needles should be used. According to Khalil the therapeutic results compare favourably with those from tartar emetic, but although the drug is more readily administered and the course is shorter, cure is by no means always attained.

Emetine

Emetine hydrochloride is advocated by Tsykalas and others, and is given intravenously in a dosage of 1½ grains daily for ten days, but although it is undoubtedly lethal to schistosomes, as found by Fairley working with animals experimentally infected with *S. spindale*, it may be followed by such severe toxic effects that the trivalent antimony compounds should be preferred. The toxic manifestations of emetine poisoning include nausea, vomiting, neuritis-like manifestations, hypotension, tachycardia, cardiac arrhythmia and even death from heart failure.

Surgery

Surgery was often necessary prior to the introduction of specific therapy but is now reserved for conditions which will not resolve under drug treatment such as stone, stricture, peri-urethral abscesses and sinuses.

Symptomatic Treatment

Pain, associated bacterial cystitis, and other complications should be treated along generally accepted lines and do not call for special comment.

II.—INTESTINAL BILHARZIASIS

(*Synonym.*—Intestinal schistosomiasis)

1.–DEFINITION

Schistosoma mansoni

Intestinal bilharziasis is a chronic disease caused by *S. mansoni*, and generally characterized by dysenteric attacks; the stools are coated with mucus in which the characteristic ova are found.

2.–PARASITOLOGY

The worms are slightly smaller than *S. haematobium* and inhabit the lower mesenteric veins and branches of the portal veins in the liver;

the eggs, which are elongated and oval in shape and measure 140–150 by 60–70 microns, possess a sharp lateral spine. The disease occurs in various parts of Africa and South America. The intermediate host is a species of *Planorbis* snail—*P. boissyi* in Africa and *P. olivaceus* in South America. The disease appears to have been carried to the New World by negro slaves from the west coast of Africa.

Intermediate hosts

3.–MORBID ANATOMY

Intestinal ulcers

The large intestine may at first show congestion and excessive mucus secretion associated with submucous deposits of eggs. Later adenopapillomas form: they may be small, sessile masses or pedunculated growths which sometimes reach an enormous size, and on sloughing leave circular ulcers in the bowel. Pericolitis and bilharzial pseudotubercles may involve the subperitoneal tissue, simulate disseminated tuberculosis, and involve the appendix.

4.–CLINICAL PICTURE

The toxic symptoms

Toxic and anaphylactoid features may appear four to eight weeks after exposure and be characterized by fever, urticaria, bronchitis, abdominal pain, enlargement and tenderness of the liver and spleen; later, diarrhoea associated with blood, and mucus containing lateral-spined ova, supervenes. The pyrexia which may last one to eight weeks is most frequently encountered in non-immune Europeans and is generally absent in natives. Localized intestinal manifestations may appear from the third month onward and be so slight as to pass unnoticed or so severe as to simulate dysentery. Acute attacks of diarrhoea with muco-sanguineous stools and tenesmus may occur at intervals, induced by chill or dietetic indiscretion. Between attacks the stools are scybalous with a coating of mucus.

Later stages

In the later stages bilharzial papillomas may form large, soft masses palpable through the abdominal wall, or they may protrude through the patulous anus causing great distress and perhaps prolapse of the rectum. Bilharzial infiltration of the buttocks and anus may lead to granulomatous formations, perineal fistulae, and occasionally epithelioma. Periportal cirrhosis and splenomegaly with or without ascites may be encountered in chronic cases and *S. mansoni* is now one of the well-recognized causes of Egyptian splenomegaly. Bilharzial involvement of the spinal cord with myelitis has been described.

5.–COURSE AND PROGNOSIS

In mild infections there is little danger to life, but in repeated infections when there is extensive papillomatosis of the rectum and colon associated with periportal cirrhosis, the outlook is less satisfactory. Modern therapy, however, results in cure except in the most advanced cases.

6.–DIAGNOSIS

Sigmoidoscopy

Sigmoidoscopy is very important. Apart from patches of infiltrated congested mucosa, small whitish bilharzial pseudo-tubercles, papules, papillomas and ulcers may be demonstrable. Scrapings from such lesions obtained with a blunt curette reveal ova. Repeated examination or concentration methods may be necessary to demonstrate ova in the stools.

Differential diagnosis

Apart from finding the ova in the mucoid coating of the faeces, sigmoidoscopy and the complement-fixation reaction are important aids in differentiating intestinal schistosomiasis from amoebic dysentery and ulcerative colitis with which it may be confused.

7.–TREATMENT

Both prophylactic and specific treatment are identical with that described for vesical schistosomiasis. Surgical intervention, including splenectomy, may occasionally be necessary in advanced cases.

III.—ASIATIC BILHARZIASIS

(*Synonyms*.—Asiatic schistosomiasis, Katayama disease, Catto's schistosomiasis, Yangtse valley fever)

1.–DEFINITION

Schistosoma japonicum

Asiatic bilharziasis is a chronic disease of the Far East caused by *S. japonicum*, characterized by initial toxic symptoms, dysenteric features with mucoid stools containing lateral-knobbed eggs, and a final stage with periportal cirrhosis of the liver, splenomegaly, ascites and death.

2.–PARASITOLOGY

Intermediate hosts

The worms inhabit the veins of the portal system, but the males differ from *S. mansoni* and *S. haematobium* in the absence of a tuberculated integument. The eggs are oval, measuring 70–100 by 50–65 microns, and possess a characteristic lateral knob. The intermediate molluscan host is *Oncomelania hupensis* in the Yangtse valley, and *Katayama nosophora* along the south-east coast of China and Japan. The disease also occurs in Formosa, the Philippines and the Shan States of Burma.

3.–MORBID ANATOMY

Advanced cases may show great thickening of the gut with scarring, and the development of papillomas on its mucous surface, shortening and thickening of the mesentery, large, firm retroperitoneal glands sometimes matted into tumour-like masses, thrombosis of the mesenteric and portal vessels, periportal cirrhosis of the liver and perhaps splenomegaly. Involvement of the lungs and brain may also occur.

4.–CLINICAL PICTURE

Apart from cercarial dermatitis which reaches a maximum in twenty-four to thirty-six hours and rapidly disappears, there are three well-defined stages. *First stage* The initial toxic stage shows irregular fever perhaps lasting several weeks, headache, urticarial rashes and transient oedemas, pain in the epigastrium or over the liver, vomiting, diarrhoea, cough and dyspnoea. Examination may reveal enlargement of the liver and spleen, râles, crepitations and dullness in the lungs and intense eosinophilia. The *Second stage* second stage is characterized by dysenteric-like attacks with mucoid or muco-sanguineous stools containing ova, frequent movements of the bowels and marked tenesmus; but sometimes intestinal symptoms are not marked. The colon may be palpable and the spleen and liver enlarged. Digestive symptoms also appear, there is anorexia with malnutrition, and *Third stage* gradually the third stage with ascites and other evidences of portal obstruction develop. Finally, hepatic insufficiency may supervene. When the brain is involved the clinical picture may include headache, vomiting, optic neuritis, various paralyses and Jacksonian epilepsy.

5.–COURSE AND PROGNOSIS

The disease, especially in cases of repeated re-infection, runs a severe course of many years' duration and frequently terminates in death. Modern treatment saves early and moderate cases, but neither emetine nor tartar emetic is well tolerated when cirrhosis is advanced.

6.–DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Eosinophilia and a positive complement-fixation reaction should enable a diagnosis to be made even before ova are demonstrable in the faeces. *Differential diagnosis* In the first stage fish poisoning, the enteric fevers, or pulmonary tuberculosis may be suspected. Dysenteric features, especially when associated with hepatomegaly, suggest amoebiasis and this will be excluded by examination of the stools and sigmoidoscopy. The late stage with portal obstruction must be differentiated from idiopathic and syphilitic cirrhosis of the liver, Banti's syndrome and tuberculous peritonitis with ascites, but laboratory tests should enable this to be done.

Cerebral symptoms

When there are cerebral symptoms and the history suggests the possibility of infestation with *S. japonicum*, detailed investigation is essential. The author recently treated for bilharziasis a naval officer from China who had been previously had a decompression, and part of the occipital lobe excised on the supposition that a cerebral tumour was present; subsequently sections of tissue removed at operation revealed a granuloma containing bilharzia eggs. Had the significance of the fact that the patient had been bathing and snipe-shooting on the Yangtse been appreciated he would have been investigated for bilharzia and received the benefit of medical treatment.

7.–TREATMENT

Treatment is in all respects similar to that outlined for *S. mansoni* and *S. haematobium* infestations.

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BILIOUSNESS

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Reference may also be made to the following titles:

AMOEBIASIS
HEADACHE
LIVER DISEASES
MIGRAINE

1.–DEFINITION

127.] 'Biliousness', or being 'liverish', is the popular term for a group of symptoms which recent investigations show to be the result of hepatic insufficiency.

2.–AETIOLOGY

Age and sex incidence

Biliousness occurs at every age but especially after forty, and is more common in men than in women. It may, however, occur in young men and girls who frequent cocktail parties, and drink cocktails, spirits and champagne without food at dances several nights a week.

Alcohol

Among the many liver poisons only those need be considered here which give rise to the milder form of hepatic insufficiency. The commonest is alcohol; over-indulgence on a single occasion may give rise to an attack of biliousness with definite signs of hepatic insufficiency, which generally disappear within twenty-four hours. Habitual over-indulgence causes a chronic condition of hepatosis.

Amoebiasis

A chronic form of amoebic hepatitis is a not uncommon cause of liverishness in those who have lived in the tropics. There is often, but by no means invariably, a definite history of amoebic dysentery. In other cases the patient has had or still has chronic diarrhoea, but occasionally there is no history of any intestinal disturbance, the amoebic infection of the bowel having been latent throughout and probably confined to the caecum. This chronic amoebic hepatitis may persist for years and very rarely goes on to severe hepatitis or hepatic abscess.

Malaria

Malaria may perhaps also give rise to chronic hepatosis and liverishness; it certainly aggravates the effect of alcoholism and amoebiasis in leading to liverishness or chronic biliousness, sometimes referred to as congestion of the liver, which is very common in men and much less so in women who have lived for long periods in tropical countries.

Acute infections

A form of infective jaundice, often mistaken for catarrhal jaundice, occurs, wherein the jaundice results from the action of the associated toxaemia on the liver cells, the hepatosis giving rise to true hepatic jaundice. This may follow influenza, typhoid and paratyphoid fevers, but most frequently the infection is non-specific. The jaundice is accompanied by toxaemic symptoms, and the laevulose test shows gross hepatic insufficiency.

3.–PATHOLOGY

Effect of toxins on liver cells

The hepatic insufficiency which gives rise to biliousness is caused by the action of various toxins on the liver cells. The resulting condition may be called hepatosis, in contrast to hepatitis, as there is no evidence of any inflammatory reaction. There is no sharp line of demarcation between slightly poisoned liver cells showing no structural changes, and the varying degrees of degeneration which culminate in subacute and acute hepatic necrosis (so-called subacute and acute yellow atrophy), although the severe and incurable forms should certainly not be included in the term biliousness.

Hepatic congestion

Nothing accurate is known about the pathological anatomy of the milder forms of biliousness, as they are never fatal. But the slight enlargement of the liver which is often present and disappears when recovery takes place, probably indicates that the liver is congested and that the liver cells are swollen; occasionally distension of the bile passages is also a factor. This may or may not disappear with treatment, but it clearly indicates that the hepatic disorder has an organic basis sufficient to obstruct the intracellular and intercellular biliary canaliculi.

Catarrhal jaundice

True catarrhal jaundice is caused by obstruction of the lumen of the common bile-duct by catarrhal inflammation associated with acute gastro-duodenitis. As the liver is unaffected, it leaves no sequel behind when the catarrh subsides and the jaundice disappears.

Habitual alcoholism

Habitual over-indulgence in alcohol produces hepatosis from which complete recovery is possible in the early stages; but even when damage of a permanent character progresses and spreads throughout the liver leading to cirrhosis, some functional improvement is still possible. This is mainly because many of the liver cells, although poisoned and functionally inefficient, are not destroyed; there is also a compensatory development of new liver cells which replace some of those which have undergone complete necrosis. The vulnerability of the liver varies enormously in different individuals; whereas very moderate indulgence in alcohol is sufficient to damage the liver in some, the consumption of a bottle of whisky a day for years does not lead to any hepatic disorder in others.

Cholesterol metabolism

Clinical experience indicates that the hepatic insufficiency associated with biliousness gives rise to disordered cholesterol metabolism, although there is no biochemical proof of this.

4.–CLINICAL PICTURE

The bilious patient feels worst in the morning. He wakes with a headache, a furred tongue and an unpleasant taste in his mouth. He has no appetite for breakfast. He has a sense of discomfort, rarely amounting to severe pain, over the right hypochondrium, which may extend to the epigastrium and round the right costal margin; it is often associated with pain in the interscapular area and in the right shoulder. His appearance is sallow, though he is not often actually jaundiced. He is generally constipated. He feels disinclined to work either mentally or physically. As the day advances the symptoms disappear more or less completely; he is often ready for a good lunch and by afternoon is able to tackle problems which appeared insoluble in the morning.

This condition may be an isolated phenomenon; if the bilious attack is the sequel of an indigestible meal or over-indulgence in alcohol the previous evening, the patient is quite well in the interval between attacks. In such cases nausea often accompanies the morning anorexia and the attack may end in vomiting.

5.–PROGNOSIS

The hepatosis, which gives rise to biliousness as a result of liver poisons, is very rarely progressive if the poison ceases to act.

Treatment generally results in rapid restoration to normal. In other cases improvement may be equally rapid, but remains incomplete owing to permanent degenerative changes in the liver; in these cases a mild degree of hepatic insufficiency may persist, which is manifested as chronic biliousness.

If, however, a patient with alcoholic hepatosis continues to consume alcohol in excess, progressive degenerative changes occur in the liver; although completely curable in the earliest stages, the damage soon becomes irreparable, and in the course of years the necrosed liver cells are replaced by new fibrous tissue till the story ends in complete cirrhosis of the liver.

6.—DIAGNOSIS

The laevulose test

The laevulose test provides definite evidence of hepatic insufficiency. If 50 grams of laevulose dissolved in 100 c.c. of water are taken fasting, the blood-sugar should not rise more than 25 milligrams per 100 c.c. in one hour and should not be more than 10 milligrams above the original figure in two hours. In biliousness the one-hour rise may be between 25 and 75 milligrams and in two hours the blood-sugar may still be well above the fasting figure.

The van den Bergh test

The van den Bergh test is generally completely negative, but occasionally, especially in the biliousness following infective hepatosis, a delayed positive direct and an immediate positive indirect reaction are obtained.

Palpation of liver

The liver is often slightly enlarged and harder than normal, and its exposed surface and lower border are always tender.

Diagnosis from migraine

It is often difficult to distinguish between a severe bilious attack and a mild attack of migraine. In other cases the 'liverish' feeling is present every morning for months or years, although it is generally associated with acute exacerbations in the form of bilious attacks following dietetic indiscretions, chills or over-fatigue.

7.—TREATMENT

Prevention

Most bilious patients learn to avoid certain articles of food which they know are likely to upset them. They may also have instinctive dislikes dating from early childhood, which are probably the result of the subconscious memory of a long-forgotten bilious attack which followed an orgy of chocolates or cream cakes.

Diet

Animal fats very frequently cause biliousness, and it is safe to prohibit cream, yolk of eggs, meat fat, pork, sausages, suet, fried food of all kinds, and chocolates, and to limit the allowance of butter. Perhaps it is the cholesterol content of these articles of diet that causes the symptoms. Their restriction often benefits the biliousness associated with gall-stones, which may persist after cholecystectomy, as the formation of gall-stones is due as much to disordered cholesterol metabolism as to cholecystitis. The close association of migraine with functional hepatic disorders is shown by the facts that the same diet is likely to reduce the frequency of attacks, and that many migrainous patients know that the consumption of cream or chocolates at night is likely to be followed by an attack the following morning.

Alcohol

Alcohol must be avoided. When it is the chief or sole cause of biliousness the patient should become permanently teetotal, as the liver will always remain abnormally vulnerable to its action. In other cases after recovery it may be allowed in moderation, but never on an empty stomach. In the more severe cases in which permanent damage has been done the patient should be warned against the use of other liver poisons, such as chloroform or avertin (tribromethyl alcohol), should he ever require an anaesthetic, and of cinchophen (atophan) for gout or rheumatism.

Glucose

In chronic cases glucose has often a remarkable effect, patients who have felt liverish every morning for months or years losing their symptoms at once. Half a pound of glucose should be dissolved in a pint of hot water and the juice of a lemon or an orange is added. Half the lemonade or orangeade is drunk first thing in the morning; the rest can be drunk when going to bed or with lunch and dinner. The glucose is always well tolerated and it is unnecessary to give insulin to promote its assimilation.

Epsom salts

Biliary drainage should be promoted by Epsom salts and olive oil, both of which cause reflex contraction of the gall-bladder and bile-ducts and relaxation of Oddi's sphincter when they reach the duodenum. The salts should be taken in concentrated solution on waking, the dose being just insufficient to cause any looseness of the bowels when no other aperient is used. Constipated patients can take a teaspoonful or more; a saltspoonful is enough for others. A tablespoonful of olive oil should be given half an hour before meals.

Olive oil

Emetine

A liverish patient who has lived in any country in which amoebic dysentery is endemic should be given a course of twelve one-grain emetine hydrochloride injections on consecutive nights, even if there is no clear history of amoebic dysentery. (See article on AMOEBIASIS, Vol. I, p. 366).

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BIRTH CONTROL

See CONTRACEPTION

BIRTH PALSIES

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2. SPINAL BIRTH PALSIES – – – – 341
3. PERIPHERAL BIRTH PALSIES – – – 341

Reference may also be made to the following titles:
ATHETOSIS CEREBRAL DIPLEGIA

128.] Birth palsies may be classified under three headings, cerebral, spinal and peripheral. In this country at least, spinal cord injuries are uncommon.

1.–CEREBRAL BIRTH PALSIES

In the past cerebral diplegia has been included in this category, but it is clear that diplegia is not related to injury to the brain at birth, but to pathological processes during intra-uterine life.

The characteristic clinical expression of a cerebral birth injury is hemiplegia, frequently accompanied by athetosis in the affected parts. It is caused by haemorrhage into the substance of the cerebral hemisphere with subsequent necrosis, by depressed fractures of the skull with laceration of the brain and occasionally by encapsulated subdural haematoma which compresses the cortex and leads to local softening.

The common diffuse meningeal haemorrhage, when it occurs in a surviving child, usually leaves no physical disability in its train. Only a trifling percentage of cases of mental deficiency can be traced to birth injury, and in these the subject is always epileptic.

Aetiology

The causes of cerebral birth injury are contracted or deformed pelvis, abnormal presentation, high-forceps delivery, extraction of breech presentations and abnormally large foetal heads. The common types of injury sustained in these circumstances are tearing of the falx associated with overriding of the parietal bones and rupture of the veins passing to the dural venous sinuses. Such lesions are found in the majority of children still-born after difficult labour, but in surviving children only the more deep-seated and severe lesions enumerated above lead to permanent residual palsies.

Clinical picture at birth

At birth the child may be deeply asphyxiated, with the pallid type of asphyxia. There may be focal or generalized convulsions. The pulse may be slow, or rapid and irregular. The child is feeble and does not suck normally. The majority of children showing these grave symptoms die, while those who survive and later prove to have hemiplegia may not show any immediate indications of cerebral injury after birth.

Hemiplegia

In most instances a severe degree of permanent hemiplegia ensues, the right side being affected as commonly as the left. In the favourable cases, power is slowly gained during the first year of life, the upper limbs recovering less than the lower. Hand and finger movements and movements of the foot and toes are most severely affected, and useful movements may never be gained in the hand. Mobile spasm, or athetosis, develops sooner or later in most such cases—sometimes only after the lapse of several years—in the affected limbs. In this condition there is considerable spasm of the interossei so that the interphalangeal joints become subluxated and the extremities of the fingers abnormally extended. The athetosis increases with the attempt at voluntary movement and may spread to other limbs and to the face and tongue. The affected limbs do not develop so well as those of the normal side and may ultimately be found to be shorter and slighter than the latter. This asymmetry tends to increase the disability. The tendon-reflexes of the affected limbs are exaggerated, but the abdominal reflexes are usually retained as on the normal side. The plantar response is commonly, but not invariably, of the extensor (Babinski) type. Sensation is unaffected. Some degree of mental defect may be found, and epileptic fits may recur through life.

Athetosis

Reflexes

Treatment

The efficacy of treatment depends upon the severity of the paralysis and upon the degree of mobile spasm present, and naturally also upon the mental development of the patient. In the presence of severe paralysis and athetosis little benefit can be hoped for, but in mild cases, especially those without athetosis, progressive improvement may occur under favourable conditions of treatment. Active educational exercises occupy the first place in treatment, and in young children it may be expedient to tie the normal arm so as to necessitate the use of the affected one by the patient. Of course, this fixing of the normal limb is carried out only for short periods at a time. Massage holds a minor place in treatment and is most useful for rigid limbs that cannot easily be employed at all. It is not a substitute for active exercises. Electrical stimulation, as in all upper motor neuron lesions, is definitely detrimental and should not be employed. Contractures and deformities, if they be allowed to occur, may call for orthopaedic treatment. If epileptic fits are present, they must be dealt with by continuous medication as in ordinary epilepsy.

Educational exercises

2.–SPINAL BIRTH PALSIES

Cause

Recent observations have shown that in infants dying during breech extraction there is not infrequently severe injury to the vertebral column and spinal cord. In the immediately fatal cases this injury is in the cervical region, but in the survivors the thoracic region is the seat of damage. When the cord lesion is complete the child rarely survives long, and during life shows a total flaccid paraplegia, with sensory loss, retention of urine and abolition of tendon-jerks in the legs. With incomplete cord lesions in the thoracic region, the child may remain with a spastic paraplegia of greater or less severity. Such cases are very rare and when they occur require the treatment indicated in paraplegia in adults.

Clinica picture

3.–PERIPHERAL BIRTH PALSIES

Causes of injury

The brachial plexus is the seat of injury in this instance and traction on the component nerves of the plexus is probably the factor mainly responsible, though it is possible that compression may play a part in some cases. Such an injury is associated with a difficult labour in which the arm has to be manipulated; for example, if in a breech presentation the arm be elevated, traction may be exerted upon it to bring it down. Similarly in head presentations it may be necessary to bring the arm down by a hook or finger in the axilla to facilitate the passage of the shoulders. When the arm is forcibly elevated and pulled backwards there may be some rotation of the clavicle, which then compresses the nerves of the plexus. Dislocation of the shoulder or even fracture of the humerus and clavicle may be associated with plexus injury. Rarely, the plexus injury is bilateral, and the writer has seen such a case in which the damage was inflicted by movements of the arms carried out to induce respiration in the new-born child. The lesion consists in stretching of the nerves, haemorrhage into their substance, and sometimes even partial rupture.

Site of lesion

The components damaged are the fifth and sixth cervical roots and the typical distribution of paralysis is deltoid, biceps, brachialis anticus, supinator longus, supinator brevis and infraspinatus (Erb type of paralysis). The position of the affected limb is characteristic. The humerus is rotated inwards, the forearm extended and the hand pronated so that the dorsum of the hand faces forwards.

Rarely the lower components of the plexus are damaged and not the upper. In this event the muscles paralysed are those of the forearm and hand. The deltoid is intact and the arm may be abducted and slightly elevated at the shoulder in a characteristic position. Bony damage is not infrequently associated with this type of paralysis. Signs of a cervical sympathetic paralysis are also present.

Sensory changes

In upper plexus paralysis there is usually no sensory loss, but in the lower plexus variety the damage to the roots is more severe and there may be extensive sensory loss over the whole of the forearm and the outer aspect of the upper arm.

Prognosis

The prognosis is good in the majority of cases, unlike that in the plexus injuries of adults, and in the less severe cases complete recovery may ensue within a few months, especially in upper plexus injuries. In other cases partial recovery may ensue. If bony injuries be associated with those of the nerves, the outlook is unfavourable as to recovery.

Treatment

Treatment is governed by the general principles obtaining in the case of peripheral nerve injuries of all kinds. The first essential is to place the paralysed muscles in a position of physiological rest, i.e. with their origins and insertions approximated. Therefore in upper plexus injuries the arm must be kept abducted and flexed at the elbow. This must be done without delay and careful passive movements of the shoulder and elbow joints, of limited range, must be carried out daily. Gentle massage helps to maintain the paralysed muscles in good condition until normal innervation is restored, but it is apparent that massage cannot have any influence upon the recovery process in the damaged roots. As soon as active movements return, the child should be encouraged to make them, since these are more beneficial than any passive procedures. The duration of passive abduction of the arm depends upon the restoration of power to the deltoid and biceps, but the arm should not be allowed to lie adducted to the side until recovery of power in the deltoid is such as to make the movement of abduction possible.

It is now generally believed that electrical stimulation of the muscles paralysed from a peripheral nerve lesion has no influence upon recovery, and if the measures indicated above be carried out there can be no justification for its employment in an infant.

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BISKRA BUTTON

See LEISHMANIASIS, CUTANEOUS

BITES AND STINGS

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Reference may also be made to the following titles:

ARTHROPODS AND DISEASE
SKIN DISEASES: AFFECTIONS DUE TO INSECTS AND ACARINES

Man may suffer direct and indirect effects as a result of being bitten or stung in nature from various sources. Toxic substances, filterable viruses, rickettsia bodies, bacteria, pathogenic protozoa, and even helminths may all be introduced during the process. Zootoxins, the products of specialized poison glands connected with an inoculation apparatus, are widely distributed in the animal kingdom and are found in certain species of spiders, scorpions and centipedes, as well as in the venomous snakes, the poisonous fishes and the platypus. Should a long interval elapse between successive stings or bites of certain of the Insecta, local or general allergic reactions may develop; occasionally these are of great intensity and may terminate in death.

1.–ARTHROPODA

(1)—Insecta

129.] These include the biting midges (Chironomidae), the buffalo gnats (Simuliidae), the sand-flies (Psychodidae), the mosquitoes (Culicidae), the biting flies (Tabanidae), the blood-sucking Muscidae including the stable-fly (*Stomoxys calcitrans*) and the tsetse-flies (*Glossina palpalis* and *Glossina morsitans*), the blood-sucking lice (Pediculidae), the blood-sucking bugs of the families Cimicidae and Reduviidae and members of the Hymenoptera, such as bees, wasps and ants.

Clinical picture

Insect venoms have an irritant action on the tissues and cause localized inflammation and occasionally also haemolytic and neurotoxic effects. Not infrequently the clinical manifestations are the outcome of an allergic reaction in a sensitized person. In these circumstances the type of local reaction appears to depend upon the depth of the inoculation. If it be into the dermis rapid whealing results, as Boycott found in the case of midge bites; if, on the other hand, the injection penetrates the deeper tissues as with the stable-fly, *Stomoxys calcitrans*, a later reaction associated with oedema of the subcutaneous tissues occurs, analogous to the delayed reaction sometimes observed to follow the intradermal inoculation of worm protein in helminthic diseases. The bitten part becomes very puffy and swollen and the surrounding skin which is stretched over it may be either pale or scarlet red according to the reaction in the more superficial vessels; although alarming at first, there is little actual pain, and the swelling generally subsides within two or three days. This is quite different from the picture produced when virulent streptococci are inoculated, producing a septic lymphangitis, or anthrax bacilli with the production of an anthrax pustule. The clinical features accompanying general allergic reactions are described in bites of the Hymenoptera (see p. 346).

(*a*) *Blood-sucking Muscids*

The Muscidae include, in addition to the stable-fly referred to above, the specialized tsetse-flies, *Glossina palpalis* and *G. morsitans*; these occur in parts of Africa, and transmit the flagellates *Trypanosoma gambiense* and *T. rhodesiense* which cause sleeping sickness. *As vectors*

(*b*) *Sand-flies*

Sand-flies (*Phlebotomus*), which are minute, hairy flies with a short proboscis, are nocturnal and bite from sunset onwards. The reaction to the bite of *P. papatasii* is dependent on a process of sensitization which takes place in a relatively short time; this is later followed by a slow process of desensitization as shown by Theodor. The skin disease in Palestine known as 'harara' is a reaction to phlebotomus bites at the height of the sensitization process. The hands, wrists, ankles and neck are especially liable to be bitten and the subsequent irritation which may recur for several days is intolerable in some people. *Phlebotomus papatasii* is the worst offender; it readily gets through ordinary mosquito netting and is the transmitter of the virus of sand-fly or three-day fever. Sand-flies also transmit Oriental sore (*Leishmania tropica*) and almost certainly kala-azar (*L. donovani*). *As vectors*

(*c*) *Mosquitoes*

The mosquitoes (Culicidae), of which the female alone sucks blood, produce variable effects in man, some species biting quite painlessly, others causing much discomfort. There is a good deal of variation in the intensity of the local reaction in different individuals; in extreme cases a large bulla may form. Mosquitoes transmit disease, and apart from occasionally inoculating virulent micro-organisms they are the vectors of filaria, malaria, yellow fever and dengue. *As vectors*

(*d*) *Blood-sucking Lice*

The head louse (*Pediculus capitis*), the body louse (*P. corporis*), and the crab louse (*Phthirus pubis*) which affects the pubic hair and is often acquired during coitus, may bite man; the resulting irritation varies widely in different individuals. Crab lice do not convey disease, but fever and a blue discoloration of the skin may result from their bites. Bites of body lice produce flushing of the skin and small rose papules which reappear for one to two days and itch spasmodically. Vesicles may form and sometimes bronzing of the skin (vagabond's disease) results. Scratching may lead to secondary sepsis. Infestation with head lice may result in eczema of the scalp, infection of glands, and insomnia in children. The spironema of relapsing fever, the rickettsia *As vectors* bodies of epidemic typhus, and the ultra-microscopic virus of trench fever, may be transmitted by infected body or head lice.

(*e*) *Bugs*

The ordinary bed bugs, *Cimex lectularius* of temperate climates and *C. hemiptera* of tropical climates, are nocturnal, and during the day live in crevices in human dwellings; *C. hemiptera* was even found in the cork lining of sun-helmets during the East African campaign. Urticarial itching wheals follow their bite, but bed bugs do not transmit disease.

As vectors

Of the Reduviid bugs, *Triatoma megista* transmits South American trypanosomiasis, and several other species may produce very severe bites although they do not transmit disease.

(*f*) *Bees and Wasps*

Symptoms

The stings of bees and wasps (Hymenoptera) are invariably painful, and if the tongue and fauces be involved respiratory obstruction may result; oedema of the glottis has occasionally led to asphyxia and death. Following a bite in a sensitized individual profound vasomotor collapse, syncope and coma may supervene; occasionally death occurs with great rapidity. In the more moderate reactions, local whealing and erythema, headache, lachrymation, conjunctival injection and chemosis rapidly follow the bite. Faintness, nausea, vomiting, well-marked lowering of blood-pressure and vasomotor collapse, laboured breathing and generalized urticaria supervene. Gradually the condition passes off, but next day a large, puffy, painless swelling due to delayed reaction in the subcutaneous tissues surrounding the bite is evident.

(*g*) *Treatment of Insect Bites*

Measures to exterminate insect pests and the destruction of their breeding places are the most effective prophylactic measures, and screening of bungalows and the use of mosquito nets at night are important. Mosquito boots prevent ankle bites, and the application of such essential oils as citronella, cassia and eucalyptus is useful, applied either directly to the clothing or as an ointment to the skin. Denver advocated spirit of camphor and cedar wood oil of each 2 fl. drachms, citronella oil 4 fl. drachms, and white soft paraffin 2 ounces, as a useful application lasting through the night. For the small biting flies, vermijelli or an ointment composed of oil of eucalyptus 5 minims, oil of turpentine 3 minims, oil of aniseed 5 minims, and lanolin 1 ounce, is worth a trial.

Curative treatment

Weak solution of iodine should be applied at once if infection is likely to be transmitted, as in bites by stable-flies. Itching is best relieved by calamine lotion to which is added solution of coal tar (2 per cent) and strong solution of lead subacetate (2 per cent), or by an aqueous solution of carbolic acid (1 in 20), or by an alcoholic solution of menthol (1 per cent).

The sting of bees and wasps should be gently removed or scraped out, as pressure applied to the part empties the poison sac into the tissues. Subsequently powdered sodium bicarbonate, dilute ammonia, alkaline soap or methylene blue may be applied locally for acid bee stings, and mild acids like vinegar for alkaline wasp stings. Should anaphylactic symptoms develop the patient must be immediately put to bed, and 10 minims of adrenaline hydrochloride solution (1 in 1,000) injected subcutaneously. Tetanus, anthrax, gas gangrene and sepsis are treated with specific antitoxins and antisera and such surgical and other procedures as may be necessary.

(2)—Arachnida

(*a*) *Mites*

Apart from *Demodex folliculorum* which is parasitic in the hair follicles, and *Sarcoptes scabiei* which produces human scabies, dermatitis may be acquired from various mites when handling raw materials, e.g. 'grocer's itch' (*Glycyphagus domesticus*), 'grain itch' (*Pediculoides ventricosus*), 'water itch' in tea plantations (*Rhizoglyphus parasiticus*), and 'copra itch'. Larval mites of the family Trombidiidae cause skin eruptions in the tropics, including the red mite dermatitis of the West Indies, and mite dermatitis in Mexico affecting the skin of the eyelids, prepuce and axilla. The harvest mite *Trombidium akamushi* conveys Japanese river fever or tsutsugamushi disease in Japan, Malaya and the Dutch East Indies, and mites are also vectors of Malayan scrub typhus and the scrub typhus of the East Indies. The harvest mite of temperate and cool climates produces considerable itching and erythema which generally begin twelve hours and increase up to thirty-six hours after the bite; extreme discomfort may result.

As vectors

Treatment

Gloves should be worn as a protection against mite dermatitis, and talc powder with flowers of sulphur or powdered naphthalene sprinkled on the stockings for the ordinary harvest mite; washing the legs with salt solution, green soap or benzene, is also advocated. Itching is relieved by applying 1 in 20 carbolic acid lotion or Roxburgh's ointment—liquefied phenol 10 minims, menthol 5 grains, zinc oxide 1 drachm, lard 1 ounce.

(*b*) *Ticks*

Ticks (Ixodoidea) are blood-sucking acarines of the families Argasidae and Ixodidae and as a rule attack man only by accident in the absence of their proper host; a possible exception is *Ornithodoros moubata* which inhabits native huts and camping grounds in Africa and transmits relapsing fever to man. Another species, *Dermacentor venustus*, is the vector of Rocky Mountain spotted fever, and in both Africa and India ticks transmit one of the typhus group of fevers. Tularaemia is also transmitted by ticks. Several species including *D. andersoni* and *D. venustus* may give rise to a paralytic disease in man; the bites, which occur generally on the nape of the neck, swell and become painful and

As vectors

oedematous, and a lower motor neuron type of paralysis follows, the legs being first involved and later the arms and neck.

Treatment

In removing ticks, liquid paraffin or carbolized oil B.P.C. should be applied before extraction is attempted, as this leads to withdrawal of the head and prevents its being broken.

(*c*) *Spiders*

The true spiders (Araneida) have poison glands and inject venom into their prey. Many species are not particularly dangerous, but some—especially *Latrodectus*—are very deadly. The so-called tarantulas of the tropics (Solifugae) are loathsome, spider-like creatures, but as they contain no poison glands their bite, though severe, is not dangerous unless sepsis ensues.

Action of venom

Spider venoms have a predominantly neurotoxic action and experimental bites or injections of the venom kill guinea-pigs with tetanoid spasms of the muscles and bronchial contractions; as in snake bite, it is believed that the venom acts on the neuromuscular junctions. Some venoms, in addition, contain a haemolysin.

Locally there may be congestive oedema or even gangrene, but often there is little obvious change. Internally petechial haemorrhages, visceral congestion, pulmonary oedema and renal changes associated with haemoglobinuria may be found.

Clinical picture

Muscular spasms and cramp-like pain are the outstanding clinical features. Pain may be so instantly severe that the patient cries out when bitten, or it may be delayed for an hour or more; it is frequently intense, radiating to the limbs, testicles or abdomen, the walls of which may be held so rigid that perforation is suspected. Features of collapse with pallor, vomiting, sweating, low blood-pressure and weakness appear early. Dyspnoea with respiratory stridor is characteristic, the pupils are contracted and later may not react to light, and the reflexes generally are sluggish. Dysphagia and priapism have also been described. Dilatation of the right heart, cyanosis, pulmonary oedema and coma may occur. The temperature is subnormal at first due to collapse but later rises, and if secondary infection ensues the fever may persist for many days. Haematuria characterized by the presence of oxyhaemoglobin and methaemoglobin in the urine results from bites of some species, including the 'cross spider' *Epeira diadema*, and *Glyptocranium gasteracanthoides*.

Latrodectus

Important species of the genus *Latrodectus* are the 'red-backed' spider of Australia and New Zealand (*L. hasselti*), and the 'black widow' of California (*L. mactans*). Both spin their webs across the seats of the dry earth closets used in country districts where sewerage does not exist, and man is generally bitten on the genitals during defaecation.

'Knoppie-spider'

'Knoppie-spider' is the colloquial name in South Africa for at least three poisonous species of *Latrodectus*, viz. *L. geometricus*, *L. concinnus* and *L. indistinctus* which cause severe symptoms and sometimes death. The two former species live in outhouses and in the walls of crevices of doors and windows, the latter in cornfields and on the veldt. In the island of Cebu in the Philippines *L. agoyangyang*, closely allied to *L. hasselti*, sometimes kills adults.

Atrax

Several species of *Atrax* are found in Australia, the most deadly being the 'funnel web' spider, *Atrax robustus*. Local pain and profound shock result from their bite, and neurotoxic features including analgesia, respiratory stridor, contracted pupils and loss of the light reflex follow. Death from pulmonary oedema and heart failure frequently occurs.

'Pruning spider'

Glyptocranium gasteracanthoides is the 'pruning spider' of Peru, so called because it is found on the under-side of vine leaves in vineyards and under fallen leaves. It gives rise to much more severe local lesions than *Latrodectus*, sometimes producing gangrene and, in addition, neurotoxic features and haematuria; death may result.

Course and prognosis

Acute symptoms generally subside after a few days but pain in the limbs and sleeplessness may persist longer. The main complication is secondary bacterial infection; this is especially a feature of *Latrodectus* bites, following which tetanus, anthrax, gas gangrene, erysipelas, cellulitis and septicaemia have all been recorded. The prognosis in most cases is good, but with *Latrodectus* and certain species of *Atrax* the death-rate reaches 6 per cent or higher.

Diagnosis

When pain occurs immediately and the spider is seen, the diagnosis is not in doubt, but when there is a latent interval and local lesions are not evident, as is sometimes the case in *Latrodectus* bites, cardiac failure, food poisoning or even intestinal perforation may be suspected—the latter owing to the extreme rigidity of the abdominal muscles.

Treatment

Inspection of dry earth closets before use would do much to eliminate *Latrodectus* bites.

Curative treatment

If the bite be located on the extremities immediate ligature, incision and mechanical suction are indicated as in snake bite. Locally ichthyol and iodine form useful applications. Injections of morphine and atropine are valuable in alleviating pain and allaying laryngeal and muscular spasm, and intramuscular and intravenous injections of calcium gluconate (10 c.c. of a 10 per cent solution) have recently been found remarkably effective for this purpose. Circulatory failure should be combated by saline (0·9 per cent) and glucose (5 per cent) solutions given intravenously, and by injections of adrenaline solution, posterior pituitary extract and possibly coramine; threatened pulmonary oedema calls for immediate venesection. Injections of convalescent serum are worth a trial if available, especially in the case of children.

(*d*) *Scorpions*

Scorpions (Scorpionida) have a partially segmented body, with powerful pincer-like pedipalps and paired poison glands located in the post-anal segment of the spined tail, which is swung forward and plunged into its prey, while simultaneously the contents of the poison sac are injected. In the tropics and sub-tropics scorpions of the genus *Buthus* and a number of others such as *Euscorpius italicus* and *Centrurus exlicauda* are much feared. The sting is very painful and toxic symptoms soon follow; they include vomiting, diarrhoea, sweating, cramps and fever, and neurological features such as trismus, stiffness of the neck, muscular paresis, coma and respiratory failure may ensue. In children death not infrequently results, and, if they survive, septic infection may supervene.

Symptoms

Treatment

Local treatment as outlined for spider bite should be instituted, and for the pain the application of strong solution of ammonia or the local injection of cocaine and adrenaline may be necessary. A specific scorpion antivenene is available; it has been widely used in Upper Egypt and has markedly reduced the mortality among children, who should receive 5 c.c. intravenously.

(3)—Myriapoda

Centipedes

Symptoms

Treatment

The only members of interest in this class are the centipedes (Chilopoda) which possess a pair of legs to each apparent segment of the body; the first pair are modified to form poison claws, and are connected with poison glands. The small centipede in temperate climates gives rise to local inflammation, to which is sometimes superadded an erysipelas-like eruption, but the larger tropical centipede *Scolopendra gigantea* may cause local necrosis, lymphangitis and general symptoms including headache, vomiting, generalized pains and fever. Coma and even death may supervene in children. Treatment is the same as for scorpion bite, solution of ammonia being a useful local application.

2.–LEECHES (HIRUDINEA)

130.] Leeches (Hirudinea) are a class of Annelid worms, and are particularly troublesome near streams and rivers and in leafy forests and marshy jungle.

The Asiatic land leech

The Asiatic land leech, *Haemadipsa zeylanica*, found in India, Ceylon, Japan and the Philippines, is only about 1 inch long and has great powers of penetrating the interstices of clothing, puttees or laced boots. Its painless bite causes loss of much blood since leech saliva contains an anticoagulant, hirudin, which prolongs the bleeding. Travellers often find their socks and boots soaked in blood and people sleeping in forests have succumbed to mass attacks. Severe secondary anaemia from loss of blood may result. Leech bites are not specifically toxic but owing to the proclivity of leeches for feeding on ulcerated areas they become carriers of bacteria and sometimes transmit infection in this manner. Tropical phagadaenic ulcer may follow leech bite.

The aquatic leech

In the Near East there is a larger aquatic leech, *Limnatis nilotica*, which, on being ingested, fastens itself to the mucous lining of the mouth, pharynx, larynx, glottis or nasal cavities of man and animals, producing prolonged and severe haemorrhage which may terminate fatally unless it is removed. This leech caused trouble in Gallipoli and Palestine during the World War and affected Napoleon's army in Egypt.

Treatment

Land leeches will get through laced boots and puttees, and top or gum boots are necessary to keep them out. As, however, they also drop from the leaves of trees and plants on to travellers, repeated search should be made for these voracious creatures. At night, a fine-mesh mosquito curtain, properly adjusted, is necessary to keep them out. Aquatic leeches can be removed from drinking water by passing it through a sieve or piece of muslin.

Curative treatment

The best treatment is the application of salt solution or of weak acid like vinegar to induce them to relinquish their hold, and then they can readily be dealt with. They should never be dragged off the skin until this has been done, owing to the risk of breaking and leaving behind their suction apparatus which is liable to cause local inflammation and suppuration. Subsequently tincture of iodine should be applied to the bites.

3.–THE AMERICAN POISONOUS LIZARDS
(*HELODERMA*)

131.] The Gila monsters (*Heloderma*), found in the deserts of Mexico, Texas and Arizona, are the only known poisonous lizards. A row of poison glands, situated along the inside of the lower lip, open at the bases of the grooved, recurved teeth in the lower jaw. The lizards chew when biting and thus may inject considerable quantities of venom into the tissues. Their bite is rarely fatal to man. Non-poisonous lizards sometimes bite man and may produce severe local sepsis of bacterial origin, necessitating surgical treatment. Bites by poisonous lizards should be treated along similar lines to snake bite. No specific antiserum, however, is available.

Treatment

4.–SNAKE BITE

(1)—Snakes venomous to Man

132.] In man, symptoms of snake poisoning result when a sufficient quantity of venom from one of the proteroglyphous Colubridae has been inoculated into the tissues. These snakes all possess a poison gland and either grooved fangs (Elapidae) or canalized fangs (Viperidae) situated anteriorly in the upper jaw. The outstanding exception to this rule is an opisthoglyphous colubrid known as the boomslang, *Dispholidus typus*, which, despite the posterior position of its fangs, is still capable of inoculating a lethal dose of venom into man. Non-poisonous snakes occasionally produce septic infection which may terminate fatally.

Poison apparatus

Snakes are carnivorous. Their venom is a specialized salivary secretion, and the poison gland, which is the homologue of the mammalian parotid, is situated behind the orbit; in the proteroglyphous Colubridae the laterally compressed venom duct passes forward along the upper lip margin to open by a papilla at the base of the fang which is surrounded by a fold of mucous membrane known as the vagina dentis. In the vipers, the fangs are long, completely canalized and capable of considerable forward elevation, whereas in the elapine colubrids they are shorter and grooved, and forward projection is very limited, being produced by a forward and upward sliding movement rather than by rotation.

Identification of poisonous snakes

In order to determine whether an unknown snake is venomous or not, it is necessary to ascertain if there are anteriorly situated fangs in the upper jaw surrounded by the vagina dentis. Then, by observing whether the fang is grooved or canalized, one can determine whether the snake belongs to the Elapidae or Viperidae respectively.

Elapidae

The Elapidae include the sea snakes (Hydrophinae) which are readily recognized by their valved nostrils and vertically flattened tails, and the terrestrial elapine snakes (Elapinae). The sea snakes although possessing very potent venom have a narrow gape and rarely bite man effectively. The elapines, on the other hand, are the most deadly of all known snakes, and include the king cobra (*Naia bungarus*), the spitting cobra (*Naia nigricollis*) and the ordinary cobras of Asia and Africa (*Naia*), the Indian kraits (*Bungarus*), the dreaded Mamba (*Dendraspis angusticeps*) of which there are black and green varieties, the deadly Australian Colubrids, including the death adder (*Acanthophis antarcticus*) and the tiger snake (*Notechis scutatus*), and the coral snakes (*Elaps* and *Micrurus*) of Central and South America.

Viperidae

The Viperidae are subdivided, according to the absence or presence of a loreal pit, into the Viperinae and the Crotalinae. The Viperinae include the puff adder (*Bitis arietans*), the formidable Gaboon viper (*Bitis gabonica*) of Africa, the horned viper (*Cerastes cornuta*) of Egypt, the *Echis carinatus* and the daboia (*Vipera russelli*) of India, and the European vipers (*V. berus*, *V. aspis and V. ammodytes*). The Crotalinae comprise the pit vipers and rattle-snakes and include the species of *Crotalus*, such as *C. adamanteus* and *C. horridus*, *Ancistrodon*, the Bushmaster (*Lachesis muta*) and the fer-de-lance (*Lachesis lanceolata*).

(2)—Mechanism of Bite and Nature of Venoms

When a poisonous snake bites, four distinct phases occur, the strike, the opening of the mouth and elevation of the fangs, the closing of the jaws with insertion of the fangs and injection of venom, and retraction of the fangs. When striking, the snake throws itself forward with great velocity for a distance generally not exceeding one-third of its length; then, as it nears its prey, the jaws open and the fangs are elevated or rotated forward by the forward swing of the pterygo-palatine-transverse arch caused by the contraction of the protractor muscles. Powerful closure of the jaws follows, produced by the contraction of the temporal muscles, which in the elapine colubrids also produces tension on the gland, expelling the venom along the duct, the papilla of which becomes approximated to the groove at the base of the fang. Fixation of the jaw is important in elapine colubrids like the cobra, and such snakes bite like a dog, often hanging on to the bitten part so that sometimes they have to be forcibly evulsed. The vipers have an entirely different anatomical arrangement of muscles acting on the venom glands; expulsion of their contents is instantaneous and quite independent of fixation of the lower jaw. Vipers, after striking, immediately recoil from the animal they are biting.

Constituents of venom

Viperine venoms

Viperine venoms contain a substance called haemorrhagin which digests the vascular endothelium and causes haemorrhages throughout the tissues, also a toxic agent producing peripheral circulatory failure, and a powerful thrombase or kinase which leads to intravascular thrombosis in small animals on subcutaneous inoculation, and to similar results in man if the venom happens to be inoculated directly into a vein, but not otherwise.

Elapine venoms

The elapine colubrid venoms, on the other hand, contain a haemolysin and an anti-coagulin in addition to a constituent which has a curare-like action at the neuromuscular junction, causing paralysis of some muscles including those of respiration.

Australian colubrid venoms

Many of the Australian colubrid venoms are mixed and contain thrombase and haemorrhagin as well as the curare-like constituent referred to above. As a rule the elapine colubrids which yield highly toxic venoms and kill by a curare-like paralysis of the respiratory muscles possess an inferior inoculation mechanism; the vipers, which have an excellent biting apparatus and kill by peripheral cardio-vascular shock and internal haemorrhage, produce less deadly venom, although its local digestive action on the tissues is much more intense and results not infrequently in severe ulceration and gangrene.

Venom yields

If snakes be milked and the venom collected and dried, it will be found that the yields vary with different species from a few milligrams to as much as half a gram in extreme instances. Factors such as captivity, disease and starvation affect the yield adversely. The lethal dose of venom also varies within wide limits, and in an experimental study made by the writer the number of lethal doses for sheep of various venoms, estimated in terms of the average venom yield, was found to be as follows: 118·0 for the tiger snake (*Notechis scutatus*), 31·7 for the cobra (*Naia tripudians*), 2·2 for the Russell's viper (*Vipera russelli*), 84·7 for the death adder (*Acanthophis antarcticus*), 8·9 for the copper-head (*Denisonia superba*) and 1·5 for the black snake (*Pseudechis porphyriaceus*). These figures illustrate the colossal potential killing power of certain elapine colubrids for animals whose body-weight approximates that of man.

(3)—Pathology and Clinical Picture

Colubrid bites

Elapine colubrid bites cause severe congestion, and death results from paralysis of the respiratory muscles; this is associated with fluid blood in the vessels, a dilated right heart, and swelling, congestion and oedema around the site of the fang punctures. After fatal viper bites there are multiple haemorrhages in the viscera, serous and mucous membranes and skin, and in man the blood is generally fluid; when, however, venom has been inoculated directly into a vein sudden death with ante-mortem thrombi in the right heart, pulmonary and coronary vessels results. Locally, the tissues are congested and infiltrated with a gelatinous, haemorrhagic exudate producing an appearance of red-currant jelly, while vessels adjacent to the bite are often thrombosed; much suppuration and local gangrene may have ensued.

Viper bites

The clinical picture depends on the species of snake, the quantity of venom injected and the body-weight of the patient, the condition being particularly dangerous in small children.

Local lesion

The local lesions caused by the colubrid snakes are generally slight and include numbness at the site of the bite; with the vipers much local pain, swelling and oozing of blood result. The two fang punctures separated by a distance of from one to three centimetres may be present, but one, three or even four fang marks may sometimes result from the one bite, the extra marks being produced by reserve fangs. Later local suppuration and gangrene may occur especially after viper bites, and chronic ulcers, or extensive necrosis, or actual gangrene of fingers, hands, feet or limbs result. The majority of patients are bitten on the lower extremity (56·6 per cent) or the upper extremity (42 per cent), body, neck and face bites being rare.

Systemic manifestations

The time of onset of symptoms is determined by the quantity and nature of the venom injected and the rate of its absorption. Symptoms may appear in from fifteen minutes to several hours after the bite and are characterized by nausea, faintness, vomiting, headache and signs of vasomotor collapse with cold extremities, blanched white skin, low blood-pressure, rapid, thready pulse and extreme prostration. Psychical shock is superadded and there are records of natives having died of fright after being bitten by non-poisonous snakes.

Elapine colubrid bites

After elapine colubrid bites, muscular weakness of the limbs, paresis of the ocular muscles, ataxic gait and frequency of micturition may occur. The speech becomes blurred and indistinct and sometimes a nasal quality is present owing to palatal paralysis. Diplopia and ptosis are characteristic and loss of sensation is often superadded. Later, swallowing becomes difficult, the tongue appears swollen, saliva dribbles from the mouth, and the breathing, which was at first intensified, becomes shallow and slow. Cyanosis now appears and coma and convulsions of asphyxial origin terminate the scene. Death in these cases results essentially from peripheral and not from central respiratory failure.

Viperine bites

In viper bites, the vasomotor collapse is very profound and there are extensive haemorrhagic extravasations which may lead to skin petechiae and purpura, epistaxis, sanguineous oozing from the gums, haemoptysis, haematemesis, haematuria and melaena. The urine may contain red blood-corpuscles at an early stage before other haemorrhagic phenomena are manifest.

Complications

Complications in viperine poisoning include local suppuration and gangrene which may necessitate amputation, while in elapine bites blunting of the cough reflex and paresis of the muscles of deglutition may result in aspiration of food into the trachea and septic pneumonia. An acute ascending paralysis of the spinal cord after krait bites has been described, signs developing after some ten days.

(4)—Course and Prognosis

The prognosis depends on body-weight, the quantity and quality of the venom injected, and the availability of specific antivenene treatment. Most first-aid measures are ineffective since ligature is applied too late, and once a lethal dose of venom has been absorbed into the circulation, antivenene is the only means of saving life. In untreated cases death may occur in from fifteen minutes to three days.

(5)—Diagnosis

Owing to psychical fright, patients bitten by non-venomous snakes may present systemic features which lead to confusion, but the absence of fang marks may help to diagnose bites of non-poisonous snakes. When the snake is available, examination of the mouth will disclose whether it is poisonous or not.

Resemblance to alcoholism

The clinical syndrome of blurred speech, diplopia and stumbling gait may lead to the suspicion of alcoholic intoxication, and occasionally patients suffering from snake bite have died in gaol through a mistaken diagnosis. In doubtful cases of viper bites, the gums should always be examined for oozing of blood, and the urine should be centrifuged for red cells; after elapine bites and in the later stages of viperine bite, the clotting time of the blood is increased.

(6)—Treatment

Prevention

Half of all snake bites are below the knee and the wearing of strong boots with leggings or puttees would do much to lessen the incidence of snake bite. Lanterns or electric torches should be used when walking at night in snake country, and people should not put their hands into hollow logs or rabbits' burrows, and should examine their boots, bedding and sleeping bags. A tent can be protected by a trench with vertical sides, and it is much safer to sleep on a camp bed with a mosquito net than on the ground when camping out.

Curative treatment

If a lethal dose of venom has been absorbed into the circulation when the patient is seen by a medical man, specific antivenene alone will save life. Deadly snakes frequently fail to inject a lethal dose of venom, especially if they bite through clothing or misjudge the strike as nocturnal snakes are prone to do in bright daylight; failure to realize this fact accounts for the extraordinary claims made for such grotesque remedies as snake stones, incantations and herbs utilized by snake charmers in

Rate of absorption of venom

various parts of the world. Experiments have shown that the absorption time of a certainly lethal dose of tiger-snake venom in naturally bitten sheep was under two minutes, while in monkeys injected locally with ten lethal doses of cobra venom it was eight minutes. Following a natural bite by a highly poisonous colubrid, a lethal dose of venom may be absorbed into the circulation in a few minutes, and in these circumstances every minute's delay in the application of a ligature is fraught with danger to the patient; when, however, the quantity of venom inoculated only approaches the order of one lethal dose, a much longer time may elapse before all the venom is absorbed and reaches the circulation. In these circumstances, ligature and other local measures may be of some service, even though their application be delayed.

Ligature

Ligature is the first and most important local procedure. A piece of thick rubber tubing (1·5 cm.) makes an excellent tourniquet, or a strip of clothing may be loosely knotted around the limb and subsequently tightened by twisting with a stick. The ligature must be applied immediately around a single bone such as in the thigh and arm, on the heart side of the bite. It must be tight enough to obliterate the arterial circulation and be left in position for at least twenty minutes; at the end of this time it may be loosened for a minute or so until the limb becomes flushed with blood, after which it can be re-applied for a similar period. By means of intermittent ligature life may be prolonged until antivenene therapy is available. Furthermore, it has recently been shown that early ligature decreases the dosage of antivenene necessary to save life.

Surgical procedures

Before surgical intervention the skin over the bite should be washed, preferably with potassium permanganate solution, to remove dried venom. Incision over the fang marks ($\frac{1}{2}'' \times \frac{1}{4}''$) reveals broken fangs, permits the application of mechanical suction, as by a breast-pump or Bier's suction glass, and affords an index to complete stasis of the circulation, but as a means of draining away venom from the fang tracks it is of doubtful value. Early free excision of the bitten tissue has more to commend it, the extent and depth of the area excised varying with the species of snake; it can advantageously be combined with mechanical suction and is the only local measure likely to be at all effective for bites on the body.

Local injections

Following the application of a ligature the tissues are injected with 10 c.c. of a 1 to 5 per cent solution of potassium permanganate or a 1 per cent solution of gold chloride. Unfortunately, necrosis and gangrene may follow, and a much more rational procedure is to infiltrate the tissues with specific antivenene, if available, especially in the case of viperine venoms which produce such intense proteolytic and haemorrhagic effects locally.

Antivenenes

With few exceptions each antivenene is antidotal only against the venom used in its production, but occasionally they give protection against venoms of allied species; this is the case with the European vipers, for which anti-jararaca serum is reported to be as effective as Calmette's serum E.R. As a rule, each country needs to produce antivenenes against its own species of snakes, and univalent, bivalent or multivalent antivenenes are now available for snake-bite cases in Europe, India, Africa, Japan, Java and Australia, as well as in the United States, Brazil, the Argentine and Central America. The dosage varies according to the concentration and titre of the preparations and is stated on the label. From 10 to 60 c.c. are generally advised, but some cases may need far more.

Snake venom being more diffusible than antivenene is more rapidly absorbed from the subcutaneous tissues. It follows therefore that after bites by the highly venomous elapine colubrids antivenene must be given intravenously, although with the less venomous species, especially the vipers, concentrated antivenenes given intramuscularly, as in the United States, appear to yield good results. If circumstances permit, the patient should be tested for hypersensitiveness to horse serum, and if necessary desensitized by injecting 0·025 c.c., 0·1 c.c. and 1·0 c.c. of serum subcutaneously at half-hourly intervals. In the absence of symptoms this is followed by a slow intravenous injection of antivenene.

Antivenene should be given at the earliest possible moment, remembering that the longer it is delayed and the smaller the body-weight the larger the dosage required. Children, for this reason, need several times the dosage which would be life-saving in an adult. Also it must be remembered that after colubrid bites paralytic symptoms may clear up after antivenene and reappear later; patients, especially children, must be carefully watched for this development and, should it occur, further antivenene should be immediately administered.

General measures

General measures include reassurance of the patient and absolute rest, warmth and stimulants such as hot black coffee, caffeine citrate, or injections of camphor in olive oil; both strychnine and alcohol should be avoided, and morphine is contra-indicated. Circulatory shock is treated by fluids given by mouth or by rectum, and intravenously as 5 per cent glucose if there is dysphagia, by injections of coramine, posterior pituitary extract or solution of adrenaline and by such measures as elevation of the foot of the bed and bandaging the limbs. Respiratory failure requires artificial respiration, and in paretic patients it is important to keep the mouth and nasopharynx free from mucus and to prevent food from entering the larynx if vomiting occurs.

5.–MEDUSAE AND FISHES

133.] Man is not uncommonly attacked by fish, especially in tropical waters, and their bite or sting may lead to severe consequences or even death. The venom of certain fish such as *Trachinus draco* resembles snake venom, producing haemorrhage and local necrosis on subcutaneous injection, and, when introduced intravenously, a primary rise followed by a fall of blood-pressure with heart failure and respiratory paralysis.

(1)—Jelly-fish (Medusae)

Portuguese man-o'-war

Jelly-fish of which the Portuguese man-o'-war, *Physalia pelagica*, is the best-known example, may be harmless or may sting very severely. Local reactions include urticarial wheals, oedema, numbness and pain extending up the limb, itching, burning and erythema; these may be followed by vesicular dermatitis, ulceration and even necrosis. Fever, muscular pains, spasm of the abdominal muscles, lachrymation, coryza, constriction of the chest, dyspnoea and cardiovascular shock may follow and deaths have been reported. Probably anaphylactic shock in a previously sensitized person constitutes the basis of the severer manifestations.

Sea-anemones

Zervos (1903) has described a disease known as the *maladie des pêcheurs d'éponge* caused by contact with sea-anemones. It occurs in the Mediterranean among naked divers collecting sponges in contact with mud and seaweed at a depth of 80 to 120 feet. Intense itchiness and pain ensue. Red papules develop and later turn blue and finally black. Sloughing and ulceration follow.

(2)—True Fishes

Tropical eels

Tropical eels (Muraenidae) are dangerous; they possess powerful non-grooved teeth between which venom collects and down which it flows from poison pouches situated above the membrane of the palate. Severe local effects, and faintness and syncope due to cardiac weakness, may follow their bite.

Scorpion fish, sting-rays

Other poisonous fish which have grooved or channelled spines or barbs in relation to adjacent poison glands are the scorpion fish (Scorpaenidae), the sting-rays (Raiae), the cat-fish such as *Cnidoglanis bostockii* and *Trachinus draco*. The clinical manifestations vary considerably.

Symptoms

Locally there is usually severe and often stabbing pain, probably associated with numbness and tingling, and rapidly ascending the limb; joint pain may be intense. Swelling and inflammation follow, and in extreme cases foetid purulent discharges, extensive sloughing and gangrene ensue and may necessitate amputation. Neurotoxic features such as paraesthesia and paralysis of the limb may occur especially with sting-rays; constitutional symptoms include fever, vomiting, cardiac weakness and vasomotor collapse, great restlessness, delirium and syncope. Death may ensue from cardiac failure or septicaemia; tetanus also has been recorded.

Treatment

Local treatment as for snake bite might with benefit be instituted if the patient is seen early enough, but no specific treatment is available. Pain is often intense and, if it is not relieved by local application of dilute solution of ammonia, morphine may be required. Cardiovascular and respiratory stimulants are indicated in the severer cases, and local complications like suppuration, abscess and gangrene must be treated along surgical lines. Amputation has occasionally been necessary.

6.–MAMMALS

(1)—The Duck-billed Platypus

134.] The duck-billed platypus (*Ornithorhynchus anatinus*), one of the Australian monotremes, is the only mammal possessing poison glands and an inoculation apparatus. The male has a canalized horny spur on the heel of its fore-foot communicating on each side with a duct descending from the femoral or crural poison gland. It is capable of vigorously injecting the contents into the tissues of man or animals; great pain rapidly follows and the parts become swollen, oedematous and tender but do not suppurate; cardiovascular shock, drowsiness, nervous depression and lethargy may ensue.

(2)—Mammals as Carriers of Disease

Vampire bats and canines

One of the vampire or blood-sucking bats of South America (*Desmodus rotundus*) has recently been shown to transmit true rabies to both man and cattle in Trinidad and elsewhere and to contain the virus in its saliva, and, as is well known, members of the canine family including dogs, jackals and wolves may convey hydrophobia to man by biting. In dogs the virus may be present in the saliva four days before the animal develops symptoms. The number and depth of the tooth marks, the intervention of clothing and the site of the bite all have a marked bearing on the prognosis. Since the virus travels via the nerves to the spinal cord and brain, face bites have a short incubation period and are particularly dangerous. Immediate local treatment includes venous compression to increase the bleeding, and carbolic acid, silver nitrate, potassium permanganate crystals or the cautery, which should be applied to each tooth mark. Lacerated wounds must be left open and on no account sutured for several days; this is especially important in the case of bites on the face.

Rat bite

Rats which bite deeply not infrequently harbour in their saliva *Spirillum minus*, and may directly transmit rat-bite fever to man.

Maulings by wild animals

Maulings by wild animals hardly come within the scope of this article, but the advisability of giving gas-gangrene antitoxin to men clawed and bitten by panthers, tigers and lions may be mentioned, as their claws and teeth are liable to contain the intestinal flora of the animals on which they prey; for this reason, gas-gangrene associated with *B. welchii* and other anaerobes is a common cause of death.

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BLACKWATER FEVER

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Reference may also be made to the following titles:

HAEMOGLOBINURIA MALARIA

1.—DEFINITION

(*Synonyms.—Fièvre bilieuse hémoglobinurique* and *Schwarzwasserfieber*. The disease is sometimes called haemoglobinuric fever, or malarial haemoglobinuria, and in the literature of the past has been referred to under various names indicating its supposed nature or origin, such as malarial haematuria, *fièvre bilieuse mélanurique*.)

135.] Blackwater fever is an acute and commonly fatal haemoglobinuria, accompanied usually by severe clinical symptoms, occurring in Europeans and individuals of certain other susceptible races resident in, or recently returned from residence in, tropical malarious countries—especially tropical Africa. It also occurs among the native population in certain malarious European countries, such as Sicily and Greece. It is rare among indigenous inhabitants of tropical regions. Blackwater fever is essentially a haemoglobinuria associated with, and in some way caused by, repeated malarial infection under certain conditions. It seems probable that quinine is the usual precipitating cause of the actual attack, although quinine, if taken regularly, prevents the disease by reducing liability to malaria.

Blackwater fever is entirely distinct in its pathological nature and mechanism from a malarial attack, but, owing to its malaria-induced origin, it is very closely associated with malaria in every detail of its aetiology.

2.–MORTALITY AND ECONOMIC IMPORTANCE

Mortality

The case mortality in any large series is over 20 per cent. In Uganda among 1,755 cases recorded in the years 1912–31 the case mortality was 23 per cent. In Macedonia during the War in 136 cases it was 26·5 per cent.

Economic importance

The high mortality and high invaliding rate from blackwater fever among government officials, planters, traders, settlers, miners, engineers, missionaries, and in general among those on whom the opening up and development of tropical regions is dependent, gives to it an unusual importance among tropical diseases. In tropical Africa especially, it is the chief obstacle to the settlement of Europeans and to the economic and commercial development of the country.

3.–AETIOLOGY

(1)—Theories of Causation

Many theories have been put forward to account for blackwater fever. In the past it has been regarded as due to some undiscovered parasite. Support for such a view has lessened, as all epidemiological studies of the disease have clearly shown its intimate association with malaria. It is known also that inoculation of man with blood from a blackwater fever case has given a negative result. In further proof haemoglobinuria, indistinguishable from blackwater fever, has been brought about in patients undergoing malaria-therapy who have never been out of England.

Relation to malaria

According to the malaria-causation view blackwater fever is essentially an induced state brought about by repeated malarial infection. The affected individual is much in the position of a patient liable to attacks of paroxysmal haemoglobinuria, except that in the case of blackwater fever it is not chill which usually precipitates the attack but unknown conditions which appear to be in some unexplained way either a final precipitating attack of malaria (not necessarily itself severe), or quinine, or both these causes acting together.

Relation to quinine

In one class of case an attack is brought on whenever quinine is administered, even sometimes in very small doses (quinine–susceptible cases). Ordinarily susceptibility to quinine appears to be temporary and of uncertain duration, so much so that to decide as to the role of quinine is difficult (see p. 365).

(2)—Geographical Distribution

Blackwater fever has now been recorded from almost all tropical and many subtropical countries, although it is much more prevalent in some than in others. A complete detailed account is given by Stephens (1927–34); the last paper contains a summary of the series.

Africa

It is especially prevalent in tropical Africa and is the cause of the high death-rate among Europeans on the West Coast, in Nigeria, the Cameroons, French Equatorial Africa and the Belgian Congo. It is also common on the eastern side of the continent in all countries from the Anglo-Egyptian Sudan to Southern Rhodesia, as well as in Madagascar and a number of the African Islands. It is common in Central America, northern South America, some of the West Indian Islands, and formerly in the United States, being recorded even as far north as the latitude of New York. Though less generally prevalent in the tropical regions of Asia (India, Burma, Malaya, French Indo-China and the Dutch East Indies) it appears to be quite common wherever Europeans or others of susceptible race reside in jungly, malarious regions and are exposed to the necessary conditions (see p. 364). In India blackwater fever is practically restricted to certain hyperendemic malarious regions where there are the necessary number of Europeans or other susceptible subjects exposed to such conditions. Little is known about the disease in China, but it appears to occur in Yunnan and elsewhere. Blackwater fever is common in a number of Mediterranean countries (Algeria, Sardinia, Italy, Sicily, Greece, Macedonia, Bulgaria, Yugoslavia), and in Palestine, Transcaucasia and Transcaspia. Cases have been reported even from Austria, Poland, Germany and Holland.

America

Asia

Mediterranean countries

Europe

It has been held that the distribution of severe malaria and of blackwater fever do not coincide, but it is very doubtful if there is any basis for such a belief. The misconception lies in confusing 'severe malaria', in itself a very vague term, with the actual malarial conditions which are known to be essential to blackwater fever. These include not only an intense degree of endemic malaria, but in addition an alien, susceptible element brought into the necessary close relationship with such endemicity. Unless each of these requirements be present, it is not likely that blackwater fever will be recorded.

(3)—Blackwater Fever Conditions

Certain special conditions appear to be necessary before blackwater fever occurs in a community. These are found in the tropics in planting, mining, or other communities living under primitive conditions in close association with severe endemic malaria. Newcomers especially usually suffer from repeated attacks of malaria, the blackwater fever supervening in a period more or less related to the frequency of this infection. Sometimes the predisposing attacks of malaria are not severe or may even be mild, but the conditions are such that even in the absence of any marked fever almost daily inoculation with sporozoites is probable, since it is characteristic of the blackwater fever environment that even a single night may be sufficient to bring about malaria infection in a stranger. In inquiring into 'histories' in blackwater cases statements regarding malaria should be accepted with caution. Genuine attacks of malaria are often passed off as merely 'feverish' or 'liverish' bouts. Further it appears that constant subjection to malaria rather than severity of the malarial attacks is the essential condition. Whatever the exact relation may be, blackwater fever most commonly occurs in communities where individuals perpetually suffer from malaria as a part of their normal existence.

(4)—Incidence

Age, sex occupation

Blackwater fever is not related to either age or sex except in so far as these determine the nature of the population exposed to the disease. Occupation similarly affects incidence mainly in so far as it necessitates living under blackwater fever conditions.

Race

Races other than Europeans commonly susceptible are Chinese, Indians and 'Syrians'. Cases among tropical indigenous peoples are rare; but the disease may occur in almost any race placed in conditions of susceptibility, e.g. negro labour in Panama, native Africans from towns or from other localities and Bengali babus in endemic Indian areas.

Family incidence

House or family incidence may be marked in certain circumstances as is to be expected when malaria is the underlying cause. So-called 'blackwater fever houses' are, for the most part, merely bungalows situated in particularly bad malarial surroundings.

Seasonal incidence

If seasonal incidence is apparent, there is usually an increased number of cases during, or following upon, the malaria season in the particular locality.

A feature of blackwater fever is its occurrence in those who, after living under blackwater fever conditions, have an attack—not infrequently their first—on returning to Europe. Such attacks may occur at any time up to some weeks or months after arrival. In such cases there is usually a history of malaria. When seen before an attack, the patient, as a rule, is obviously suffering from malaria with parasites in the blood.

(5)—Residence

Attacks at a period of residence of less than three months are unusual. Cases are not uncommon between the third and sixth month of residence where exposure to malaria has been exceptional. From six months to two years may be taken as the usual period for frank exposure to blackwater fever conditions. Stephens (1913) in a survey of 1,050 cases found the maximum incidence in the second year.

Early cases

A large number of cases occur in later years of residence, but local knowledge will frequently show that, from change of locality or other reason, the subject has been especially exposed to malarial infection at some period preceding his attack.

Late cases

Following upon the first, there are commonly subsequent attacks. A third attack usually results in death or the patient being invalided from the country.

(6)—Relation to Quinine

In the usual type of blackwater fever case the relation to quinine is obscure, since it is found that, shortly after an attack apparently precipitated by quinine, a further dose has no such effect. The question of causal relationship has been especially studied by Stephens and Stott (1915), who found a correlation with a lag of three hours between the usual time of taking quinine (6 to 9 a.m.) and the onset of blackwater fever (9 a.m. to 12 noon). The difficulty in arriving at a conclusion is the frequency with which a dose of quinine is taken under blackwater fever conditions when an oncoming attack of malaria is suspected. The evidence, however, in general supports the view that there is a causal relationship, although cases apparently occur in which no quinine has been taken.

Usual type of case

Cases showing a definite susceptibility, in that an attack is precipitated whenever quinine is administered, appear as a rule to originate after one or more attacks of the usual type. Yorke quoted the case of a child, at first normal in respect to quinine, who later developed an attack of blackwater fever whenever quinine was administered and after residing some time in England showed a lessened but still present susceptibility.

Quinine-susceptible case

There is no evidence that haemoglobinuria occurs in quinine poisoning or as an individual idiosyncrasy in those who have not lived in a blackwater fever country. The action in precipitating an attack of haemoglobinuria would therefore seem to be quite a special one bearing some relation to the malaria-induced state.

4.—PATHOLOGY

(1)—Pathogenesis

Blackwater fever in its general features resembles haemoglobinurias of other origin, from which it is to be distinguished mainly in its aetiology and general clinical characters. Apart from the fact that malaria in some way brings about liability to attack, and that quinine, at least in many cases, precipitates such an attack, nothing is known as to the essential pathological processes concerned.

It is almost certain, however, that the process of blood destruction is that characteristic of a 'haemoglobinuria' with 'intravascular haemolysis', as distinct from that occurring in an 'attack of malaria', and in many other conditions in which the red-cell destruction is mainly intracellular.

In intracellular destruction of red cells (engulfment, phagocytosis) haemosiderin is formed with haematogenous bilirubin, giving an indirect van den Bergh reaction. The former is dealt with by the cell, the haematogenous bilirubin is removed as bile and not excreted in the urine. If the bilirubin is in excess it gives rise to haemolytic jaundice and urobilinuria. In intravascular haemolysis, haemoglobin is liberated as free circulating protein and is broken down by the reticulo-endothelial cells of the spleen, liver and kidneys. The haemoglobin is also excreted as such by the kidneys. This is not so in intracellular destruction, however great this may be (see Fairley and Bromfield, 1933).

Site of haemolysis

It is not known how far the haemolysis takes place in the general circulation or is effected locally in some organ or organs. There is a good deal to be said for the suggestion by Yorke that haemolysis goes on to a large extent in the venous sinuses of the spleen and that the products pass later into the circulation.

(2)—Pathology of Blood and Urine

The frequency with which malaria parasites are found in the blood in blackwater fever depends largely on the stage at which the examination is made. Stephens (1903) gives the number of positive finds in 150 cases on the day before onset, the day of onset and the day after onset as 95·6, 61·9, and 17·1 per cent respectively. When the disease is well advanced parasites are usually very scanty or not to be found. Presence of pigmented leucocytes may be taken as evidence of recent infection, but even these may be rare. Puncture of the spleen and even post-mortem material in some cases does not yield evidence of any considerable degree of malarial infection.

Species of parasite

In 75 to 95 per cent of cases the parasite is *P. falciparum*. At Panama, however, among 89 cases Deeks and James (1911) recorded 23 with *P. vivax*; and Stephens (1915) recorded a case, and referred to 7 others in the literature, in which the only parasite found was quartan. While it is probable that in the tropics at least *P. falciparum* is the predominant causative parasite of blackwater fever, other species may also play a part.

Red cells

Early in the disease, the red cells do not noticeably differ from normal in appearance, although decreased in number. Shadow corpuscles (stromata), if present, are usually not numerous. After the third or fourth day, however, striking changes are seen in microscopical preparations of the blood owing to regenerative changes (reticulocytes, large pale cells, polychromasia). At this time reticulocytes may form 20 to 30 per cent of the total red cells.

Colour index

Even though the number of red cells be greatly reduced, the colour index at first may be normal. Later in the period of regeneration it may be lowered.

Leucocytes

A marked reduction in polymorphonuclear cells usually follows an attack. There may be a relative increase in the large mononuclear cells, when not masked by polymorphonuclear increase during the high temperature. Large plaque-like transitional and endothelial cells, often containing included decolorized corpuscles, are highly characteristic.

Haemoglobinaemia

Haemoglobinaemia is usually not very obvious. Most frequently the plasma is of an orange tint, due to yellow coloration and some degree of haemoglobinaemia. In general the haemoglobinaemia amounts to from 0·5 to 2·0 per cent whole blood equivalent. It was stated by Yorke to be much less than is seen in paroxysmal haemoglobinuria, or in haemoglobinuria from *Babesia*. According to Fairley and Bromfield (1934) methaemoglobin is present in considerably larger amount than oxyhaemoglobin, but is apt to be underestimated since it does not yield so marked a spectrum. Including both oxyhaemoglobin and methaemoglobin, the plasma content may be from 3 to 5 per cent.

Methaemoglobin

Acidosis

Acidosis does not appear to be marked, as once thought, and recent observers have found no significant reduction of the alkali reserve. In severe cases this may be above normal, due probably to the vomiting. Blood cholesterol may be low during the attack and increased later, but not to any notable degree, nor invariably so. At least an equal reduction may occur in malaria. The blood urea is increased when the kidneys are affected.

Blood cholesterol

Blood urea

Urine

The early urine shows chiefly oxyhaemoglobin. Later methaemoglobin is present. Urobilin may be present prior to an attack or entirely absent. It is present in large amount during and following the attack. The urinary deposit consists of granular material, renal cells and characteristic brown granular casts. Red cells are absent in the earlier stages but may be present in the later stages.

(3)—Changes in the Organs

These are mainly the effect on the kidneys of excretion of the products of haemolysis; and of the disposal of such products by the tissues, liver cells, etc. In the spleen there is some evidence of toxic effects as shown by small necrotic foci. The tissues are very characteristically stained a light yellow colour.

Kidneys

The kidneys are usually large and appear deeply engorged. The glomeruli are little changed, but Bowman's capsule may be dilated and show some exudate. The convoluted tubules exhibit marked changes in the epithelium, with desquamation of the cells. Lower down in the tubule the lumen is packed with an accumulation of granular eosinophil debris, composed of desquamated and altered cells, which in suppression cases appears to have caused mechanical blocking. According to Baker and

Dodds (1925), if the pH of the urine is above 6·0, haemoglobin is excreted in unchanged form. If the pH is below 6·0, and in the presence of 1 per cent NaCl (haemin formation), brown pigment is deposited in the tubules.

Liver
Gall-bladder
Spleen
Bone marrow

The most striking feature in the liver is the abundance of characteristic coarse yellow pigment in the liver cells, giving a Prussian blue reaction (haemosiderin). Malarial pigment may be present in the endothelial cells. The gall-bladder is characteristic, being distended with thick curdy dark green bile. The spleen is enlarged. Microscopically small necrotic areas are commonly seen especially in the central portion of the Malpighian bodies. The bone marrow is hyperplastic, usually with a marked relative increase in eosinophil marrow cells and numerous giant bone-marrow cells.

5.–CLINICAL COURSE

Types of disease

Considerable differences in the intensity of attacks occur. Most usually cases of medium or severe type are encountered running a fairly typical course. Some mild cases consist of little more than the passing of some haemoglobin in the urine and may easily escape attention. Very severe cases rapidly ending in death are not uncommon.

History

The history usually follows that given under 'blackwater fever conditions' on p. 364. Prodromal symptoms of malaria and fever are usual. There may be a history of a previous attack. The most important point is residence in a country or under conditions where the disease might be expected to occur.

Onset

Onset is usually sudden, with subjective symptoms which suggest to the patient an oncoming attack of malaria. Either the passing of haemoglobinous urine or a rigor may be the first indication. As a rule the temperature is high when the patient is first seen.

Urine

The first urine passed is dark reddish (port-wine colour) but may be light red, darkening afterwards. Subsequent specimens are usually darker and may give an almost blackish appearance in bulk (porter colour). On standing, the urine, especially the later specimens, shows a voluminous characteristic brownish flocculent deposit. The spectroscope shows bands of oxyhaemoglobin and later methaemoglobin. Albumin is present in large amount. The quantity of urine passed varies a good deal. Usually the total quantity during the twenty-four hours is somewhat above normal. A severe type of case with polyuria may occur. In mild cases there may be a gradual return to normal after a variable period of haemoglobinous urine. What appear to be renewed periods of blood destruction commonly occur, the urine again darkening after it has lightened in tint. Associated with this there may be further rigors. Unless the condition clears up within two or three days there is usually a reduction in the amount of urine. This may end in complete suppression, which is an ominous sign and may occur as early as the second day of the attack but is more commonly seen on the third or fourth.

Temperature

Shortly after the onset the temperature rises from 103° to 105° F., and commonly remains high so long as the blood destruction continues, thereafter returning more or less gradually to normal. There may be violent, irregular oscillations. Frequently a high temperature continues for a week or more after the haemoglobinuric process has ceased (post-haemoglobinuric fever). Hyperpyrexia may occur.

Blood

A profound anaemia rapidly develops. The red cells may become reduced by about a million in the course of twenty-four hours. With a prolonged attack or several periods of haemolysis the count may fall to two million or less. Malaria parasites are either scanty or absent unless the case is seen early. Apart from reduction in number, the red cells show little alteration under ordinary examination until later regenerative changes occur. Auto-agglutination may be present. The plasma may be yellow or show an orange tint or rarely even a marked rosy tint of haemoglobin. Distinction should be drawn between plasma and serum in recording haemoglobinaemia.

Haematogenous jaundice

After a variable period, almost from the onset in some cases, yellowness of the conjunctivae is observed. A similar tint in the skin soon follows and generalized yellow coloration of the whole body is usual after the first twenty-four hours.

Condition of the patient

The patient is prostrated and weak. Vomiting is usual and is the most distressing symptom. Thirst and complete anorexia are usual. Epigastric pain is commonly complained of, and, when the kidneys become involved, pains in the loins also. In the later stages the patient is often restless, excited and light-headed, with incoherence of ideas and some degree of hallucination. Headache may be severe. There may be profuse sweating. Diarrhoea may be marked. Hiccup is of bad prognosis. Terminally there may be delirium, convulsions or coma.

Death

Death is usually due to anoxaemia from blood destruction, cardiac failure, or the renal complications. Sudden death from syncope may occur and should be guarded against. Death may occur with hyperpyrexia. In some cases a condition of asthenia continues after the haemoglobinuria has ceased and the patient gradually becomes comatose and dies.

Relapses

Apart from renewed crises in the attack, relapses coming on within from one to ten days are common. They may be of equal duration with the first attack but are generally milder in character.

Recovery and convalescence

Provided suppression of urine does not supervene, or a febrile condition continue after cessation of the attack, convalescence is usually uneventful. The chief complications are continuance of high temperature, relapses, or subsequent attacks of malaria with the question of treatment of this condition to be considered. In all cases there is a danger of further attacks if the patient should return to the environment in which he contracted the disease.

Prognosis

Prognosis at all stages should be extremely guarded. After recovery, prognosis is good if the patient can be suitably invalided. There is no certainty, however, that a further attack may not develop even after return to Europe, and much depends on the effectiveness with which after-treatment for malaria can be carried out and the patient's condition kept under observation.

6.–DIAGNOSIS

Spectroscopic verification

The essential point is to make sure that the condition is one of haemoglobinuria. Haemoglobin bands should be determined with a pocket spectroscope in various dilutions of urine (see Plate VI, facing p. 499). The urinary deposit should be examined for red cells or stromata and for the characteristic brown granular debris and casts. If the bands are not seen and the urine is red, malingering may be considered. A perfect imitation of blackwater urine, which may even deceive one familiar with the disease, can be made from 'pan', i.e. from the colouring matter of the catechu and lime usually employed with the leaf and added, after chewing, to the urine. The patient may await an attack of fever before producing such evidence. If, however, a haemoglobinuria is definitely established, there is little likelihood of the condition being other than blackwater fever. Haematuria may occur in yellow fever or Weil's disease, but not haemoglobinuria. Paroxysmal haemoglobinuria must be excluded by the history and circumstances.

Differential diagnosis

7.–TREATMENT

Apart from prophylaxis (see p. 372) there is no known drug or specific method of controlling the haemolytic process in blackwater fever. Attempts to do so on rational lines, e.g. administration of cholesterol, have led to no definite result, and in many cases are based on very doubtful premises. Treatment therefore consists in (*a*) amelioration of the patient's condition generally, and careful nursing; (*b*) action directed to protect the kidneys and prevent onset of the usually fatal suppression; (*c*) transfusion, if practicable, in suitable cases.

Although blackwater fever is caused by malaria it is an entirely distinct condition, and there is no indication that quinine is beneficial to it. The contrary is the case, since quinine is suspected to be in many cases the precipitating cause of the haemoglobinuria. Further, even if parasites are present they may be expected speedily to disappear. Under ordinary conditions, therefore, neither quinine nor any other anti-malarial drug should be given during the course of a case of blackwater fever. Deaderick records a mortality of 25·9 per cent in 1,006 cases treated with quinine and one of 11·1 per cent in 472 cases in which quinine was withheld. Lovelace gives a mortality of 11·6 per cent for 436 cases treated without quinine.

At an interval of from four to ten days after an attack, parasites usually reappear and treatment for malaria is then imperative. In such circumstances quinine may safely be given, but treatment should be instituted with caution, commencing with small doses. It is probably more advisable to use atebrin, but also with caution.

Care of the patient

Transport of a case over any distance should be avoided if arrangements for treatment can possibly be made on the spot. Complete rest in bed, with day and night nursing, is essential. Chill should be carefully guarded against. Food should be restricted. At most, milk diluted with soda water, orange juice, etc., will be required. Antipyretics are contra-indicated on account of the tendency to cardiac failure.

Vomiting is commonly severe and distressing and should be controlled by the usual methods. Morphine sulphate $\frac{1}{10}$ grain; small doses of morphine and hyoscine; ice-bag on head; ice in mouth; sips of iced champagne or of very hot water; 10 minims of adrenaline solution (1 in 1,000) in water; mustard plaster over the epigastrium—all these methods have been recommended. Continuous vomiting must be prevented, since, apart from other reasons it tends to deplete the salt and water stores in the body and to diminish the urine. Headache may be treated by cold applications to the head and behind the ears.

Protection of kidneys

Protection of the kidneys is the one outstanding feature, over and above merely symptomatic treatment, to which attention should be directed. The indications in general are to maintain an alkaline urine and its free flow by every possible means.

Every effort should be made to administer by mouth as much alkaline fluid as possible. Natural lemonade, barley water, Vichy or other similar mineral waters, sodium bicarbonate or sodium citrate (30 grains to the pint) may be given for this purpose.

If by reason of excessive nausea, administration of fluid by mouth is attended with difficulty, rectal enemas of sodium bicarbonate (120 grains to the pint, half a pint at a time) may be given every few hours, or more frequently; or the same may be administered by the drip method. A preliminary large enema of soap and water is desirable. Glucose (5 per cent) in the above quantities should be given alternately with the alkali if the patient is restless.

If enemas are not being absorbed, recourse may be had to saline (1 per cent) run into the subcutaneous tissues of the flank. Intravenous injection of physiological saline or sodium bicarbonate solution has been recommended but is considered dangerous owing to the liability of right cardiac failure.

Suppression

If suppression is threatened, hot enemas (100° F.), hot fomentations over the loins, or dry cupping over the kidneys may be employed.

Biocholine

With the aim of increasing the cholesterol content of the blood, biocholine (solution of choline hydrochloride) has been tried in Indo-China by various French medical authors.

Other drugs

Calcium chloride, adrenaline, arsenicals (neo-arsphenamine), antivenene and crotalin are among those substances which have been employed with the idea of controlling the haemolytic process, but these must be regarded as of uncertain rationale and effect.

Blood transfusion

In an increasing number of instances in England blood transfusion has been employed with apparently successful effect, especially when a condition of asthenia supervenes. Blood grouping must, however, be suitable. About 400 c.c. of citrated blood may be given. See article on BLOOD TRANSFUSION, p. 536.

Convalescence

Albumen water, milk, chicken broth, Benger's food and such preparations, should be followed in due course by a generous diet rich in proteins and vitamins. Treatment to prevent subsequent malaria is important. A change or invaliding is indicated.

Prophylaxis

Prophylaxis is the most urgent indication where blackwater fever is prevalent. This should take the form of protective measures against malaria, and all bungalows should not only be screened but specially designed and constructed to this end. Electric fans should be installed, as otherwise screening is unlikely to be effective. A spacious, sitting-out, protected verandah is essential. All details necessary to render screening effective must be carefully observed in accordance with those requirements prescribed by experience. Covell's 'Malaria Control', the League of Nations' publication on housing and malaria (Christophers and Missiroli, 1933), and the section on malaria in this work should be consulted.

Measures of personal protection should be the subject of instruction and clearly explained. Meticulous attention should be directed to the type of mosquito net used—the manner in which this is employed at night and how disposed of by day. Suitable protection for the ankles and an inner garment under the trousers should be worn as a routine as soon as evening approaches.

Regular use of quinine sulphate, 5 grains a day, is recommended in circumstances in which the individual, in spite of general precautions, is for any reason unable to maintain effective protection.

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BLADDER DISEASES

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Reference may also be made to the following titles:

BILHARZIASIS
COLIFORM BACILLUS INFECTIONS
HAEMATURIA
URINE EXAMINATION

1.–NEOPLASMS

136.] New growths of the bladder may be divided into those that are epithelial in origin and those that are derived from connective tissue. Epithelial growths are by far the commoner, connective tissue growths such as fibromas, myomas and sarcomas being so rare that they need not be considered. Epithelial growths must be subdivided into benign and malignant, the commonest representative of the benign being a papilloma and of the malignant, papillary carcinoma, adeno-carcinoma and epithelioma. It should, however, be realized that although these are different clinical entities, there exists a very marked tendency for growths which at first were innocent to become, when they recur, more malignant in type. A patient who first comes to the consulting-room with what is definitely an innocent papilloma may eventually, if recurrences continue to appear, develop what is an unmistakable papillary carcinoma. Since innocent and malignant growths are different clinical entities requiring different methods of treatment they will be considered under separate headings.

(1)—Vesical Papilloma

Aetiology

There is little exact knowledge of the origin of papillomas, but the fact that they are generally situated in the vicinity of the ureteric orifices suggests that some irritant in the urine may cause their appearance. The incidence of bladder growths is particularly high in populations engaged in the aniline dye industry, more especially amongst those working with benzidine and naphthionic acid.

Clinical picture

Haematuria is the commonest and often the only symptom of papilloma of the bladder. Indeed it may be said that painless haematuria in a young adult is strongly suggestive of this condition. The blood is characteristically bright red and is mixed with the urine, but occasionally it is more marked at the beginning of micturition. Even if at first copious, after a few days' rest the bleeding ceases, to return with increasing frequency and severity as the papilloma grows. Rarely there is a slight aching pain in one kidney due to the fact that the papilloma is situated in the neighbourhood of a ureteric orifice and gives rise to an increase in intra-ureteric and intra-pelvic pressure. A pedunculated papilloma situated at the neck of the bladder may also produce spasm or difficulty in micturition. If untreated, papillomas in time become so large and so numerous, and bleeding so continuous that profound anaemia results.

Cystitis is uncommon in the case of innocent growths unless infection has been introduced by instrumentation, but is, on the other hand, a frequent complication of malignant papillomas. Owing to the fact that innocent growths in course of time tend to become malignant, cystitis must be regarded as one of the later complications of the disease.

Course and prognosis

Because of the likelihood of recurrent papillomas of the bladder becoming malignant some writers have looked upon them as a precancerous condition. This is more especially true of papillomas occurring in the middle-aged or elderly.

Diagnosis

As has already been stated, painless haematuria in a young or middle-aged adult is most likely to be due to papilloma of the bladder. Very rarely fragments of papilloma are found in the urine and the tentative diagnosis confirmed by microscopic examination of them. It must not, however, be assumed that because the microscope shows these detached fragments to be benign in character, that this is necessarily true of the rest of the growth. The surface of a papilloma may appear to be innocent, whilst an examination of its deeper portions may reveal characters of malignancy. Palpation of the bladder from the rectum gives negative results unless the growth is very large and firm.

Cystoscopy

It is by the cystoscope that an exact diagnosis is made, and cystoscopy is absolutely essential in all cases of unexplained haematuria. A patient who has had a slight bleeding which has stopped will often object to what he considers an unnecessary examination, but as a growth may increase to three or four times its original size before another accidental bleeding occurs, cystoscopic examination must be insisted upon.

A papilloma is seen through the cystoscope as a round or irregular projection covered with tendrils of varying length, which float in the distending fluid and are stirred by every current. It resembles a sea-anemone and even through the cystoscope it may be seen that each of its villi has a fine centrally placed vessel with lateral branches.

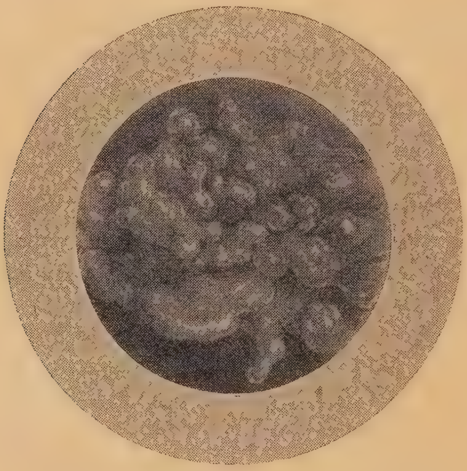

FIG. 56.—Papilloma of bladder (Thomson-Walker collection)

The tumour is most frequently placed on the upper and outer aspect of the ureteral orifice. Often the growths are multiple, and tiny buds are found scattered over the surface of the mucous membrane surrounding the main papilloma. A suspicion of malignancy should be aroused if the growth be sessile, the villi short, the growth solid in appearance, and the surrounding mucosa oedematous, ridged or puckered.

Examination with irrigating cystoscope

Sometimes it is difficult to obtain a satisfactory view when the examination is made in the presence of severe bleeding. In such a case an irrigating type of cystoscope should be used, with which it will be possible to obtain a clear field even when bleeding is profuse. It must be borne in mind that occasionally a bladder papilloma is secondary to a primary papilloma in the renal pelvis or ureter. Sometimes tags of papilloma are actually seen protruding from the ureteric orifice at the time of cystoscopy. When the growth is very large, the lamp of the cystoscope may be plunged into such a wilderness of villi that the light is obscured and no view obtained. This is only likely to happen in cases of long-standing haemorrhage.

Treatment of papilloma

The treatment of papilloma is always operative. Only if the condition is hopelessly advanced and the patient in a state of extreme debility can merely palliative measures be considered. Treatment will then resolve itself into the treatment of complications and symptoms. Of these haemorrhage is the most important. Should this be severe the patient should be kept in bed and morphine or opium administered. Calcium lactate in doses of 10 or 15 grains may also be given every four hours. Ergot also has its advocates but in the writer's experience it has rarely proved effective. Washing out the bladder usually increases rather than diminishes haemorrhage, and always carries with it the risk of introducing sepsis. If it is employed, the best solution to use is silver nitrate (1 in 10,000) at a temperature of 110°–120° F. Should retention be caused by clots and not yield to catheterization the clots may be extracted by passing a large evacuating cannula such as is used in litholapaxy. After this has been done a catheter with a large eye may be tied in for twenty-four hours. Instrumentation, however, carries with it a very grave risk of sepsis and should be employed only if absolutely essential. Should this attempt to get rid of the clots and restore micturition fail, suprapubic cystotomy must be carried out. Haemorrhage may, however, continue even in an empty bladder draining through a suprapubic tube. Radium in such cases will often have a good effect. It should be introduced through the suprapubic opening in sufficient quantity to stop haemorrhage without producing a severe reaction. *Radium*

There are two chief operative methods for dealing with vesical papillomas: by means of diathermy (fulguration), and by an open operation and excision.

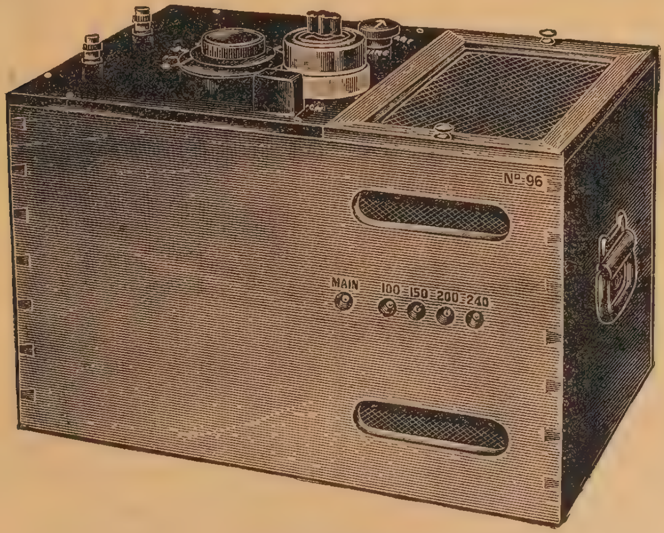

FIG. 57.—Diathermy apparatus, spark-gap type

Diathermy The introduction by Beer in 1910 of the high-frequency current in the treatment of bladder growths has revolutionized treatment of this condition. The bipolar current is most commonly used by British surgeons. The apparatus I employ is that made by the Genito-Urinary Manufacturing Company of the spark-gap variety (Fig. 57). One pole is connected with a large flat indifferent electrode which is placed over the pubes, the lower lumbar region, the thigh or whichever area is most convenient. The active electrode is in the form of a fine copper wire heavily insulated and passed through an operating cystoscope (Fig. 58). For diathermy of papillomas an irrigating instrument should always

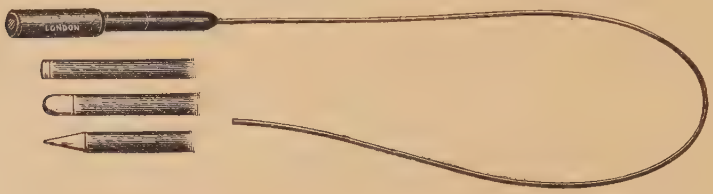

FIG. 58.—Electrode for diathermy of papilloma showing three different types of extremity

be used, in order that a clear field may be maintained throughout the operation (Fig. 59).

Anaesthesia The operation may be carried out under local, low spinal or caudal anaesthesia. If the patient is nervous a general anaesthetic may be

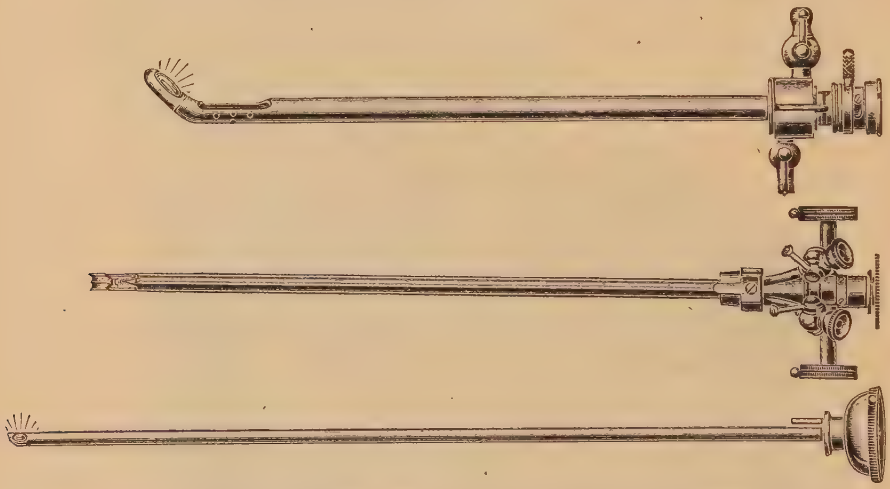

FIG. 59.—Irrigating catheterizing cystoscope suitable for diathermy of papilloma

advisable. For local anaesthesia 5 per cent procaine hydrochloride (novocain) or 1 in 1,000 percaine solution is instilled into the urethra, particular attention being paid to the anaesthetization of the posterior portion. The patient is placed in the lithotomy position, the legs, perineum and lower abdomen being covered with sterile towels.

Should the papillomas be multiple it is useful to construct a chart showing their precise distribution before starting treatment. This diminishes the risk of missing some of them and also provides a record to which to refer on subsequent occasions.

The simplest form of active electrode is that shown in Fig. 58, the size selected being the largest that can be introduced through the operating or catheterizing channel of the cystoscope. For extensive growths requiring a great deal of fulguration an electrode with a large surface is an advantage, and some form of brush or ball electrode (Figs. 60 and 61) is particularly useful.

Technique of fulguration

After locating the growth the electrode is advanced under full ocular control so as to make contact with the papilloma. If possible it should be applied to the pedicle or to the stem of a large branch. The current used should at first be weak and its strength gradually increased. The current is turned on and off by means of a foot switch.

Duration of applications

Visible changes occur in the growth at the site of contact with the electrode, a white area appearing which gradually extends into the neighbouring tissues. At the same time bubbles of hydrogen are liberated from the surface of the electrode. Applications are made for 20 to 30 seconds, a different area being attacked on each occasion. When the electrode is withdrawn white shreddy masses of necrotic growth will be seen to be adhering to it and in time the end of the electrode may become so encrusted with these that it is necessary to withdraw it in order to clean it.

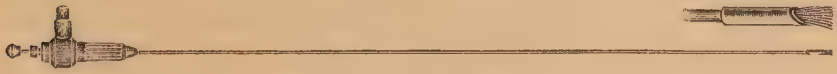

FIG. 60.—Brush electrode

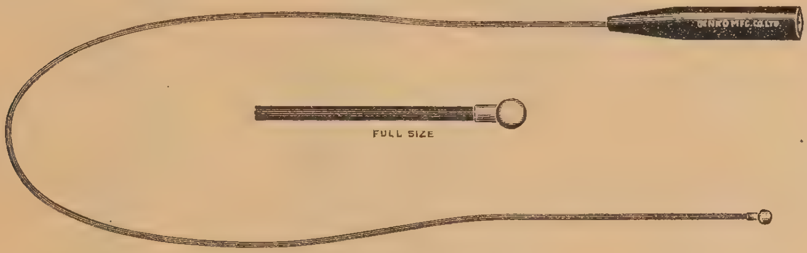

FIG. 61.—Ball electrode

The field of view may sometimes become obscured either through bleeding or through the collection of gas bubbles. The former is dealt with by means of irrigation and the latter by revolving the cystoscope so that the bubbles are allowed to escape to the upper part of the bladder.

Duration of treatment

Since the growths are devoid of nerve-fibres, the only pain occasioned to the patient is that resulting from a prolonged cystoscopy. The duration of the treatment will depend on the tolerance of the patient and may vary from ten minutes to three-quarters of an hour. At the end of the sitting the bladder should be washed out with weak silver nitrate solution (1 in 1,500) and a form of urinary antiseptic given by mouth. If the growths are extensive, it is unlikely that they will be destroyed at one sitting and a second session should be arranged at an interval of two to three weeks, by which time the sloughs will have separated and the operator be in a position to estimate how much more treatment will be required. When the patient is intolerant, or the growth very extensive or difficult to reach, spinal or general anaesthesia will be necessary in order that a longer session may be possible.

When the papillomas are very large the end of the cystoscope is buried in them and the field of operation so obscured that fulguration may seem a hopeless task. Nevertheless by doing what is possible at each sitting, the condition may so rapidly improve that what seemed at first beyond the scope of intravesical surgery, may be carried to a successful conclusion.

If for some reason the case is considered unsuitable for diathermy, the growth must be excised. The steps in this operation are as follows:

Excision of growth

After distension of the bladder with a weak solution of silver nitrate (1 in 4,000), it is exposed through a median suprapubic incision and the peritoneum is stripped from its upper surface. The bladder is then opened, its contents evacuated, a suitable retractor inserted and the patient placed in the Trendelenberg position.

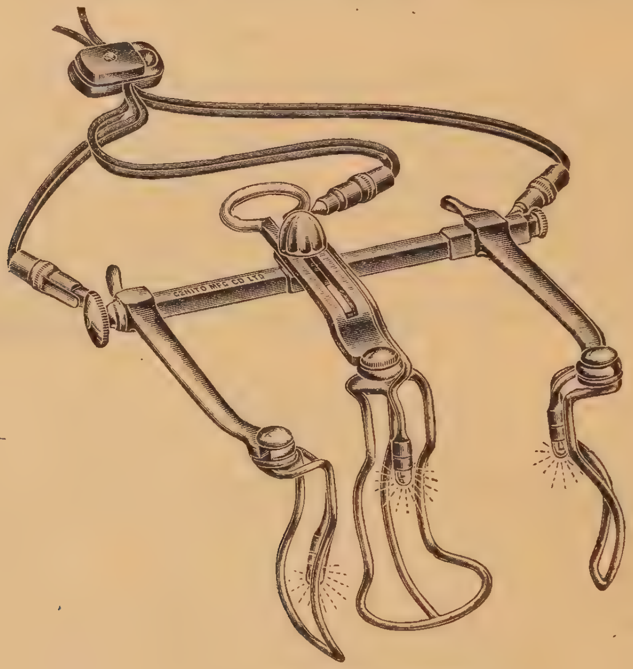

FIG. 62.—Morson's illuminated bladder retractor

Under good lighting the interior of the bladder is then inspected. If the retractor shown in Fig. 62 be employed no extra outside source of illumination will be required but if this is not available a suitable operating lamp, so arranged as to throw its light into the interior of the bladder, will be of great service. The number and position of the papillomas are first noted and reference made to the cystoscopic chart previously prepared. To diminish the risk of detaching fragments of growth that may become implanted into the wound, the papillomas should first be swabbed over with a 5 per cent solution of silver nitrate. The mucous membrane at about half an inch distance from the growth is then picked up with forceps and raised from the muscular coat. With long, thin curved scissors the mucous membrane is then cut across and the incision extended to separate off a plaque of mucous membrane surrounding the whole of the growth. If the papilloma is large, or if bleeding be excessive, suturing with fine catgut should be carried out simultaneously with excision.

Risk of implantation

Whilst removing the papilloma care should be taken to avoid contact between the growth and the raw area left by the excision in order to reduce the risk of accidental implantation. When great masses of papillomas fill the bladder, a rapid operation must be performed and carried through in spite of bleeding. The bladder may then be temporarily packed with iodoform gauze. Sometimes the ureter comes into the field of operation and in excising papillomas in its neighbourhood special care must be taken not to include its lumen within any suture.

Combination of two methods

In a few cases of widespread papillomas excision may be combined with open diathermy, the larger mass being dealt with by the scissors and the smaller outlying buds by a diathermy electrode. This method should, however, only be adopted in exceptional cases, since fulguration is likely to increase the risk of sepsis.

Repair of the bladder and abdominal walls is carried out in the usual manner. Rarely will primary closure be possible, and drainage by means of some form of suprapubic tube is necessary. The post-operative treatment is the same as that employed in other cases of cystotomy.

Choice of operation

The intravesical method is always preferable and should be carried out unless some definite contra-indication exists. It must be remembered that bladder growths tend to recur even when they are innocent and that with each recurrence they show a tendency to become malignant in type. Swift Joly has stated that recurrence is more frequent after excision than after diathermy, and that the prognosis is generally worse with multiple than with single growths. The only hope of safeguarding the patient lies in thoroughness in treatment and in periodic cystoscopy afterwards in order to catch recurrences in their earliest stages. Such an examination should be made every three months for a year and then every six months until three years after the first treatment.

For papilloma due to infection by *Schistosoma haematobium* see BILHARZIASIS, p. 327.

(2)—Malignant Growths

Classification

Fortunately malignant growths remain for a long time localized in the bladder, and it is usually only in their later stages that metastases are formed in the lung, pleura, liver, spleen or kidney. Pathologically malignant growths may be divided into papillary carcinoma, adenocarcinoma and epithelioma. Clinically they may be divided into those that originate in a normal bladder and those that have developed in a previous lesion, as in the case of a papilloma whose recurrences have in time become malignant, or an epithelioma that has arisen in connexion with chronic irritation of the bladder.

Symptoms

The onset of symptoms is usually insidious, the most frequent, as in the case of an innocent bladder growth, being haematuria. Owing to the fact that malignant growths infiltrate the bladder wall, the haematuria is generally associated with other symptoms such as frequency of micturition and pain. The pain may be due to associated cystitis, to obstruction due to blood-clot, or to the infiltration of nerves. It is radiated along the urethra towards the tip of the penis, but may also be felt in the suprapubic region, the perineum or even down the thighs. In the latter event, intravesical infiltration of the sacral nerves must be suspected. When cystitis is present, the urine contains pus and mucus.

In the later stages of the disease, the urine is usually alkaline, loaded with phosphates and foul smelling. Emaciation is marked and uraemic symptoms are added if ascending infection of the kidneys has occurred. The majority of patients dying of malignant disease of the bladder die as the result of a combination of haemorrhage, cachexia, sepsis and uraemia.

Diagnosis

Thomson-Walker subdivided cases of malignant growth of the bladder into two chief clinical types, the cystitis type and the haemorrhagic type, according to whether the main symptoms are those of irritation or of bleeding. Bimanual examination may reveal the presence of shotty enlargement of the inguinal glands, and rectal examination of infiltration of the base of the bladder, associated in advanced cases with enlargement of the lymphatic glands draining that area.

Cystoscopy

As in the case of innocent growths, cystoscopy is the most important step in the examination. Since the examination is often painful, a spinal or a general anaesthetic may have to be given. The cystoscopic picture will depend on the type of growth that is present. A papillary carcinoma may at first sight resemble an innocent papilloma, but it is more likely to be sessile, and its villi to be stunted, more closely packed and more irregular. Signs of infiltration of the surrounding bladder wall are also present in the form of thickening, puckering and oedema. An adeno-carcinoma is recognized by its solid appearance and its smooth surface, and the associated signs of infiltration. In the case of an epithelioma there may be very little projection of the tumour above the surrounding bladder wall, but marked ulceration, the base of the ulcer being dirty and frequently encrusted with phosphates. Signs of infiltration of the bladder wall are much in evidence.

Cystography

Cystography may also be employed as a means of diagnosis, the cystogram showing imperfect filling of the bladder in the neighbourhood of the growth. The information so obtained is, however, far less accurate and reliable than that provided by cystoscopy.

Treatment may be divided into operative and non-operative, radical and palliative.

Operative treatment

The chief hope of cure lies in excision of the growth with sufficient surrounding margin to prevent recurrence, in other words, in partial resection of the bladder. Owing to the fact that the majority of malignant growths are situated in the neighbourhood of the trigone, complete extirpation is often impossible. A decision whether to operate or not must be based on the size of the growth, the rapidity of its spread, the involvement or not of the ureters, the severity of the associated cystitis, the existence or not of extensions outside the bladder and the general condition of the patient. In order to obtain a satisfactory answer to these questions, a preliminary examination under an anaesthetic will often be necessary.

Partial resection

In favourable cases the operation of partial resection may be carried out. The first steps of the operation are the same as those for excision of a papilloma. The incision of the bladder must be well away from the growth. If the growth is situated on the posterior wall, the viscus is incised in the most convenient position and the peritoneal cavity opened so that the peritoneal aspect of the bladder may be carefully examined. An area of peritoneum subjacent to the growth is then marked off with scissors, and the peritoneal cavity closed leaving the marked-off area adhering to the bladder. The cystotomy wound is then carried back so as to surround the growth in a racquet-shaped incision that includes within it not only the growth but also a good margin of healthy bladder wall. As the section proceeds, spouting vessels are ligatured and catgut traction sutures inserted at half-inch intervals. Should the resected area involve the ureteric orifice, the lower end of the ureter must be exposed outside the bladder and cut across. At the completion of the resection, the divided end of the ureter is implanted into the bladder wherever may be most convenient. After removal of the growth the bladder is reconstituted by the insertion of interrupted catgut sutures from below upwards. If the excision has involved the ureter, an additional drain should be placed in the extravesical space and brought to the surface at the side of the suprapubic tube.

Total cystectomy

Owing to the fact that many cases of malignant disease of the bladder do not reach the surgeon until late, resection will often be found to be impossible. In order to get rid of the growth it would be necessary to remove the whole of the bladder. Total cystectomy has been carried out, but it is such a severe operation that many surgeons feel it is unjustifiable. If it is performed some method of deviation of the urine must be adopted. The preliminary operation therefore consists of implanting the ureters into the rectum or bringing them to the surface of the body. If the patient survives this procedure, total removal of the bladder is carried out subsequently. The high operative mortality of cystectomy in the past is partly due to the fact that the operation of deviation of the urine has sometimes been performed simultaneously with removal of the bladder. Even if this mistake is avoided, the operative mortality remains in the neighbourhood of 75 per cent.

X-ray therapy

Should resection be impossible, reliance must be placed on radium or deep X-ray therapy. Up to the present deep X-ray therapy has given poor results. Quite apart from the difficulty of destroying a bladder growth by such means, X-rays have an irritating effect on the bladder wall and may convert a mild into a severe cystitis. In a series of thirteen cases treated by X-rays, quoted by Thomson-Walker, there was no improvement in eight, some improvement in four, and disappearance of the growth in one.

Radium treatment

Treatment by radium is on the whole more satisfactory. The radium may be applied by a radium bomb, by needles or by the insertion of radon seeds. The bomb treatment suffers from the same disadvantages as deep X-ray therapy. The insertion of radium needles into bladder growths through a cystotomy opening has, in the writer's cases, resulted in more harm than good, for the breaking down of the bladder and the irritation to the surrounding mucosa is liable to be followed by an increase in sepsis and an exaggeration of pain and discomfort.

Radon seeds

The only satisfactory method of applying radium is by the insertion of radon seeds. This is done through an operating cystoscope, the seeds being fixed on the end of a special introducer resembling a ureteric catheter (Fig. 63). When in the right position, they are released by pressing a handle at the end of the introducer. By connecting the introducer with a diathermy current, electro-coagulation may be carried out simultaneously with the introduction of the seeds. This method can be applied only if the growth is conveniently situated; it is inapplicable to growths on the anterior wall.

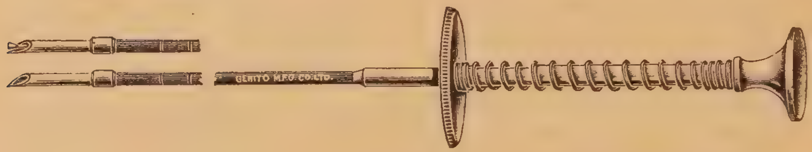

FIG. 63.—Introducer for the cystoscopic implantation of radon seeds

Palliative treatment

Severe haematuria in inoperable cases may be treated in the same way as haematuria resulting from the presence of an innocent growth (p. 375). Should these measures prove ineffective, radium should be tried. If a suprapubic wound exists, a container with a sufficient quantity of radium is inserted directly into the bladder. When there is no suprapubic opening the radium may be applied in the form of a plaque over the pubes.

Treatment of pain

Pain may be due to chronic cystitis or to infiltration, and is treated by giving a suppository of liquid extract of belladonna, 2½ minims, with morphine hydrochloride, ¼ grain, or analgesics by the mouth. If the pain is very intractable and is not relieved by these palliative measures, division of the pre-sacral nerves may be considered. Afferent fibres carrying the sensations of painful distension and spasm travel in the pre-sacral nerves to the 11th, 12th and 1st segments, and division of these nerves will block some of the pathways of pain. Pain due to involvement of the pelvic parietes in the growth can only be relieved by morphine and sometimes by X-rays.

2.–STONE

137.] A vesical calculus may be primary or secondary, a primary calculus being one that is formed within the bladder, and a secondary calculus one that has reached the bladder from the upper urinary tract, generally the renal pelvis. Stones forming primarily in the ureters are such rarities that they need not be considered.

Aetiology

The majority of vesical calculi are primary and the result of obstruction associated with sepsis. Climate, race, diet and heredity may play a part but their influence is small compared with that of local conditions. That this is so is shown by the fact that vesical calculus is at the present day far less common than formerly, the diminished frequency of incidence being due to improvement in the early treatment of obstruction and sepsis. It is also supported by the observation that bladder stone is about twenty times more common in males than in females, the higher incidence in males being due to their greater liability to difficulty in micturition associated with sepsis. Vesical calculi may also be classified according to their composition, but the majority are formed of a mixture of all the commoner crystalline components. As rarities may be mentioned calculi formed of cystine, xanthine and fibrin.

Sex incidence

Symptoms

In cases of secondary calculi bladder symptoms are usually preceded by attacks of renal colic. These attacks are often followed by a temporary cessation of symptoms, which alter in character when the stone enters the bladder, and are followed in turn by symptoms due to its being swept into the urethra and causing difficulty and pain. Frequent micturition is the commonest and earliest symptom. Urgency is often noted and a feeling of discomfort or pain at the end of voiding. These symptoms are aggravated or sometimes only provoked by exercise, especially exercise involving jolting of the lower part of the body. Pain is usually felt at the tip of the penis, but sometimes in the perineum or above the pubes. Haematuria is terminal, a few drops of blood being squeezed out at the end of micturition. It is never severe and is influenced by rest and exercise in the same way as are the other symptoms.

A significant sign is the sudden stoppage of the stream in the middle of micturition due to impaction of the stone at the internal meatus. The patient may notice that if he lies down, he is able to pass water again on assuming the upright position.

When cystitis is present all the symptoms are increased, and night frequency is added to day frequency. If a stone has developed in association with an enlarged prostate, characteristic symptoms are often absent, owing to the fact that it lies comfortably ensconced in the depths of the retro-prostatic pouch.

Diagnosis

Many of the symptoms of vesical stone occur in other bladder conditions, but the fact that they are increased by jolting is significant. Moreover, the pain in calculus is particularly sharp and is exaggerated at the end of micturition when the inflamed bladder wall is pressed down on to its hard surface. Unless the calculus is large it is not likely to be detected by abdominal, rectal or bimanual examination. It may be discovered on the passage of a sound. In order to sound the bladder the patient should lie on a high couch with the surgeon standing on his right side. Four or five ounces of weak antiseptic lotion are introduced into the bladder through a catheter, and a short-beaked bladder sound is passed. The beak of the sound is turned first to one side and then to the other, the instrument being slightly withdrawn with each successive exploration. When the beak of the sound comes into contact with the stone a sharp metallic click is heard and an impact imparted to the thumb and finger holding the instrument. Multiple calculi can be diagnosed if the impact takes place when the beak is turned first to one side and then to the other.

Radiography

Valuable information may be obtained by means of radiography. The shadow cast by a vesical stone lies usually in the middle line and can be made to change its position by moving the patient. Difficulty is sometimes experienced in differentiating the shadow cast by a vesical stone from one cast by a stone in the lower portion of the ureter. A vesical calculus may also be simulated by a calcified fibroid or by a phosphatic concretion lying in a diverticulum.

Cystoscopy

Cystoscopy is the most certain method of diagnosis. Not only will the cystoscopy reveal the fact that the patient is suffering from a bladder calculus, but it will give information about associated conditions such as prostatic enlargement, bladder diverticulum, cystitis, and bladder growth. If the prostate is enlarged it may be impossible to see a calculus, owing to the fact that it lies within the depths of a prostatic pouch.

Treatment

Extraction of stone

A small calculus is passed spontaneously, and if the symptoms suggest that a ureteric stone has entered the bladder, time should be allowed for its being voided during micturition. Should this not happen, it should be extracted by means of a Bigelow's evacuator. This method is, however, only applicable to small stones which have recently descended from the kidney or to fragments of concretions of phosphates formed during the course of a chronic cystitis. If a calculus is too large to be dealt with in this way, two operations are possible, litholapaxy and lithotomy.

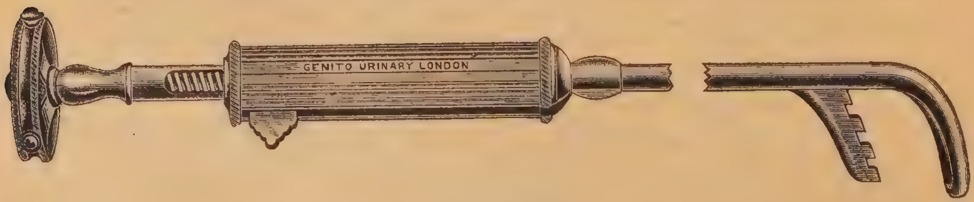

FIG. 64.—Lithotrite

Litholapaxy

Litholapaxy (or lithotrity) consists in crushing the stone by means of a lithotrite and then evacuating the fragments by means of a Bigelow's evacuator. The lithotrite (Fig. 64) consists of two blades, one of which lies within the groove of the other. By means of a mechanical device in the handle, the two blades can be separated and approximated so as to grasp between them and crush the stone.

The operation of litholapaxy is carried out in the following manner. A general anaesthetic is administered, a catheter passed and the bladder washed out with warm boric acid lotion, four or five ounces of solution being retained at the end of the washing. Standing on the right side of the patient, the surgeon introduces the lithotrite with the blades approximated. After it has been passed, the handle is raised so that the beak descends to the lowest part of the bladder. The blades are then separated and the stone lying at the lowest part of the bladder will often be found to have rolled between the blades so that it is caught when the two are approximated by means of the mechanism in the handle. Should this not happen the blades are again separated and the instrument turned to the right or to the left, different areas of the bladder being explored at each trial. When the stone has been grasped it is crushed, but before crushing the operator must be sure that the instrument lies free in the bladder and that no mucous membrane is included within its jaws. Lithotrity is continued until no more fragments can be grasped. The blades are then closed and the instrument withdrawn. In order to evacuate the fragments the largest sized Bigelow cannula that the urethra will admit is passed, an internal meatotomy being carried out in order to do this if necessary. After emptying the bladder, four or five ounces of fresh fluid are injected, the aspiration bulb applied to the cannula and the cock opened (Fig. 65). Raising the bulb in the middle line so that the beak of the cannula lies at the lowest part of the bladder, the bulb is sharply compressed and then allowed to relax. With each diastole of the rubber bulb fragments of stone are sucked into the evacuator, the aspiration being continued as long as these appear. If fragments too large to enter the cannula are present in the bladder, a clicking noise may be heard made by their impact against the eye of the cannula. Should this happen the lithotrite is again introduced and further crushing carried out. The operation is repeated until the fluid withdrawn by the evacuator contains no traces of stone. In order to ensure that nothing has been left behind, the bladder may finally be examined by means of an irrigating cystoscope. If cystitis be present

Evacuation of fragments

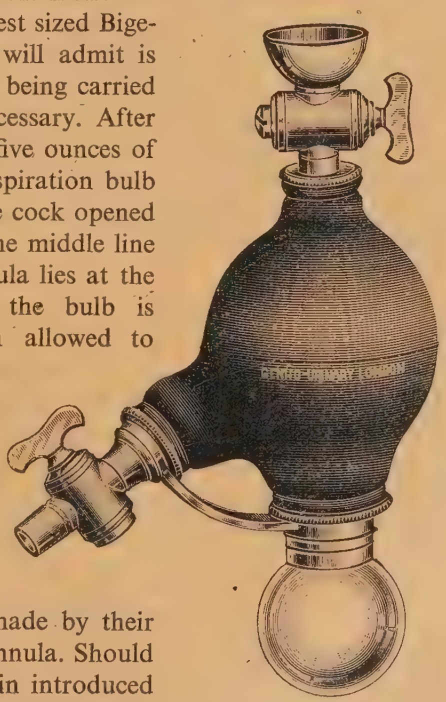

FIG. 65
Bigelow's evacuator

or the outlet obstructed by prostatic enlargement, the bladder should be drained for a few days by means of an indwelling catheter. During this period it is washed out daily with silver nitrate solution (1 in 10,000).

Although litholapaxy is especially suited to the treatment of calculus in adults it may also be carried out in children. For this purpose a small-sized lithotrite and cannula will be required.

Suprapubic lithotomy

To perform suprapubic lithotomy, the bladder is exposed and opened through a median suprapubic incision. The finger is then introduced and the calculus palpated lying at the lowest part of the bladder. It is extracted by means of lithotomy forceps. If numerous small stones are present, or a friable calculus, care must be exercised to avoid leaving behind fragments which can form the nuclei of fresh stones. When the calculus is very large the opening into the bladder must be sufficient to permit its extraction without undue bruising of tissues. If the stone lies in a diverticulum, excision of the diverticulum together with its stone should be carried out (p. 401). At the conclusion of the operation, the bladder is drained suprapubically. If the stone is small and the bladder uninfected, primary closure of the bladder with catheter drainage may be possible.

Choice of operation

Litholapaxy has many advantages over lithotomy since it entails less shock to the patient and a much shorter convalescence. It should therefore be carried out as a routine except in the presence of definite contra-indications. Litholapaxy is not advisable when the stone is encysted, when it is very large, or when it is associated with severe cystitis, a diverticulum, a bladder growth or prostatic enlargement. It is also contra-indicated in very small children. There is no difference in recurrence after the two operations when carried out by an experienced surgeon.

Recurrence

Recurrence of stones is due either to the continuation of the conditions which led to their previous formation or to the presence of fragments accidentally left behind that have served as nuclei for the formation of fresh stones. Treatment therefore must not be limited to the extraction of the calculi, but must also include treatment of the conditions that have favoured stone formation. The patient who is left with a pool of residual urine, or with a chronic infection of the bladder, will undoubtedly return with a new stone within a short time.

3.–FOREIGN BODIES

138.] Foreign bodies may reach the bladder through the urethra or through the bladder wall. When they gain entrance through the urethra they have usually been introduced by the patient, generally in order to excite erotic sensations. This occurs more frequently in women, and a large variety of objects varying from a hairpin to a bust of Napoleon have been found in the female bladder. Of the foreign bodies penetrating the bladder wall, the commonest are silk sutures used in operations upon the pelvic viscera and splinters of bone from a bone abscess or a fracture of the pelvis.

Symptoms The symptoms are those of cystitis. If the foreign body has a smooth surface it may remain quiescent within the bladder for a considerable time until it becomes encrusted with phosphates. This always occurs in time and the symptoms are then identical with those of vesical calculus. Retention of urine may occur if the foreign body falls over the internal meatus. Foreign bodies, such as sutures penetrating the walls from without, are usually associated with symptoms of pericystitis.

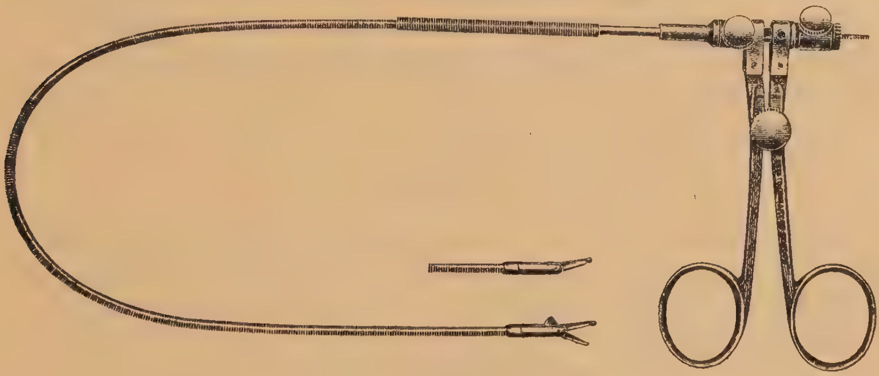

FIG. 66.—Cystoscopic scissors

Diagnosis Sometimes the history of the introduction of a foreign body may be elicited, but more often than not, the patient is too ashamed to give any information on this subject. An examination is called for on the suspicion of vesical calculus or because of chronic cystitis. An X-ray examination may reveal the outline of a hairpin or some such familiar object and cystoscopy may prove that it is within the bladder.

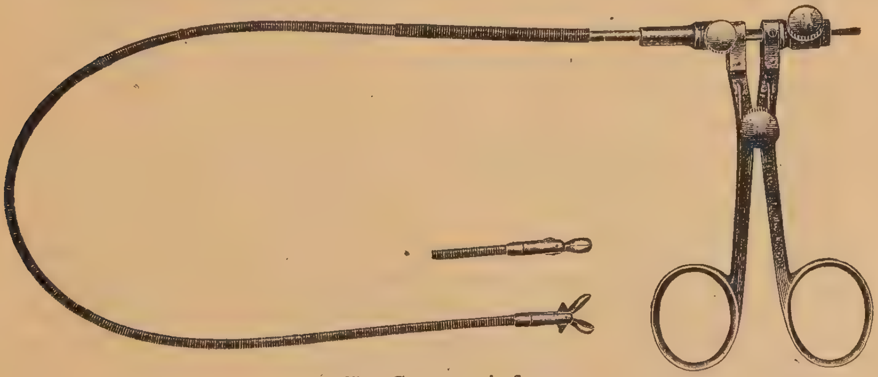

FIG. 67.—Cystoscopic forceps

Treatment Extraction per urethram is usually only possible in the female. If a Kelly's tube be passed, the patient placed in the Trendelenberg position and the bladder distended with air, the foreign body may often be seized by means of fine long-armed forceps. Help in doing this may be obtained by inserting the finger into the vagina. When this method fails the bladder must be opened suprapubically and, should severe sepsis be present, a temporary drainage established.

When the foreign body is encrusted with a thick layer of phosphates, the true condition of affairs may not be recognized until the difficulty in crushing it arouses a suspicion that the object is not an ordinary calculus. If the cystoscopic examination reveals the presence of a silk suture attached to the bladder wall, it may be divided by scissors working through an operating cystoscope, and then extracted by means of forceps (see Figs. 66 and 67).

4.–TUBERCULOSIS

Aetiology 139.] Tuberculous cystitis is always secondary to a focus elsewhere in the body. Usually it is secondary also in the sense that it is an extension from a lesion in another part of the urinary tract—more particularly the kidney. It occurs most frequently in youth or early adult life and more commonly amongst males than females. In the male it may occasionally happen that the bladder has been infected by extension from a tuberculous vesicle and prostate, but extension from the genital tract is far less common than extension from the kidney.

Formerly it was thought that the bladder was infected through the blood-stream, but more thorough methods of investigation have shown that it is more usually inoculated by urine descending from an infected kidney. When infection by the blood takes place, tubercle of the bladder is of the miliary variety and an incident in a general miliary tuberculosis. Vesical tuberculosis should be regarded as a phase in tuberculosis of the genito-urinary tract.

Prognosis Left to itself bladder tuberculosis is a fatal disease. Although interrupted by periods of slight amelioration of symptoms, the disease is slowly progressive, and ends with uraemia as the result of bilateral renal tuberculosis.

Symptoms The symptoms are those of a spontaneous cystitis occurring in a young man or woman. Sometimes the bladder symptoms have been preceded by symptoms pointing to an infection of the kidney, but, as often as not, renal tuberculosis is silent and attention is first called to the patient's condition when the bladder becomes involved.

Frequency of micturition is the earliest and commonest symptom. At first moderate and noted only by day, the frequency gradually increases so that sleep is disturbed. Frequency is followed by urgency and this in turn by pain. Pain, in the form of burning radiated to the end of the penis, is more likely to be felt when the patient attempts to hold water too long. Haematuria may be an early or a late symptom. When it is copious the bleeding usually comes from the primary focus in the kidney. Bleeding from the bladder rarely consists of more than the passage of a few drops of bright blood at the end of micturition.

The onset of the disease is insidious and its progress gradual and persistent.

Diagnosis

The urine will usually be found to be acid and of low specific gravity. Microscopic examination reveals the presence of pus and usually of red blood corpuscles. When sewn on ordinary culture media it is found to be sterile. Pyuria with an acid sterile urine is strongly suggestive of tubercle. Sometimes, however, secondary infection has occurred and the diagnosis is masked by the detection of other organisms. Should a young adult suffer from a persistent cystitis and no reason be found for his failure to improve under suitable treatment, a careful search for tubercle bacilli must always be made.

The proof that a cystitis is tuberculous rests on two foundations, the discovery of the tubercle bacillus in the urine and the cystoscopic appearance of the bladder.

Examination of urine

Since tubercle bacilli are usually present only in small numbers in the urine, repeated examinations may be required before they are found. The discovery of the bacillus is assisted by collecting a twenty-four-hour specimen of urine. By sedimentation, a deposit is obtained which on being subjected to some enrichment method may reveal the presence of the tubercle bacillus. If in spite of repeated negative results a clinical suspicion of tuberculosis still exists, a guinea-pig should be inoculated. This is the most sensitive of all tests and may be considered crucial in spite of the fact that a few cases have been reported of infection with a tubercle bacillus that is non-pathogenic to a guinea-pig.

Cystoscopy

With a tuberculous bladder cystoscopy is often difficult and almost always painful. For this reason a spinal anaesthetic may have to be employed. The earliest stages of tuberculous cystitis appear through the cystoscope as patches of erythema surrounding small miliary tubercles. Later on superficial ulceration appears with thickening of the bladder walls.

Since tuberculous cystitis is almost always secondary to a primary focus in the kidney, changes in the appearance of the ureteric orifices are of paramount importance. In the earlier stages these changes may be the same as those occurring in the case of a non-tuberculous pyelitis, namely, erythema and slight oedema. This is soon followed by thickening, the appearance of tubercles, and still later, ulceration. In a still more advanced stage, the ureter is open and trumpet-shaped or of the golf-hole variety described by Fenwick. Cystoscopic examination makes it possible not only to confirm the diagnosis but also to discover the condition of the kidneys.

Examination of ureteric urine

The success of future treatment depends on the power of the surgeon to make an exact diagnosis and it is essential that he should know which kidney is infected and which is not. In order to do so, catheterization of the ureters to obtain specimens of urine from each kidney may be necessary. If one ureteric orifice is definitely tuberculous and the other apparently healthy, only the healthy side need be catheterized, but when doubt exists specimens should be obtained from both kidneys.

These specimens are examined for the presence of pus, tubercle bacilli and other organisms. Red blood corpuscles in the urine are of no significance since catheterization alone is able to produce slight haematuria. Renal function tests may also be carried out while the ureteric catheters are still in position.

In advanced cases the bladder may be so retracted and the field of view so obscured by bleeding from extensive ulceration that catheterization cannot be carried out.

Indigo carmine test

Useful information may be obtained by injecting 10 c.c. of 4 per cent indigo carmine solution intravenously and noting the time that elapses before the dye appears at each ureteric orifice. Should a blue efflux be noted on one side at the end of seven or ten minutes and no blue appear from the opposite kidney, say, after a quarter of an hour, it may be assumed that the delay is due to infection of that kidney.

Other methods of examination

When cystoscopic methods fail to give satisfactory information as to the state of the kidneys, reliance must be placed on intravenous pyelography, bimanual palpation, and in a few cases, palpation of the ureters through a laparotomy wound.

Treatment

Nephrectomy

Treatment is based on the fact that tuberculous cystitis is a secondary lesion of the bladder resulting from a primary focus elsewhere. Treatment therefore consists in extirpation of the primary focus, in other words in nephrectomy. Fortunately in the earlier stages of the disease the infection is confined to one kidney, and prompt operation will not only lead to an improvement in the bladder condition but also safeguard the opposite kidney from subsequent involvement. Nephrectomy is followed by a gradual improvement, and in the majority of cases the cystitis completely disappears.

Ureterectomy

Should the ureter be badly involved, ureterectomy may have to be performed in addition to nephrectomy, and statistics have shown that the results of nephro-ureterectomy are slightly better than those of nephrectomy alone.

General measures

When bilateral tuberculosis is present, the prognosis is unfavourable and reliance has to be placed on general treatment alone. This entails residence in warm, dry climates, nourishing food, and as much fresh air and sunshine as is possible.

All articles known to irritate the urinary tract, such as condiments, highly spiced foods and alcoholic drinks, must be avoided, and plenty of milk and eggs and cod-liver oil provided. If the infection is a mixed one, urinary antiseptics should be used, but in cases of tubercle they usually have very little effect.

Tuberculin

Drugs

Tuberculin has given satisfactory results in some cases and should therefore be tried. The initial doses should be small and all severe reactions avoided. Although no drugs have a direct curative effect they may be useful in relieving symptoms. Amongst those recommended for pain and frequency are guaiacol or sandalwood oil in 5 minim capsules, belladonna, and hyoscyamus.

Local treatment is generally productive of more harm than good. Not only does washing out the bladder often lead to an increase of symptoms, but also it carries with it a risk of introducing secondary organisms. Especially is this so in the male. A possible exception may be made of instillations of gomenol in very painful and irritable bladders. Injection into the bladder of a mixture of 20 per cent gomenol in sterile olive oil may sometimes bring relief. Some authorities have recommended that tuberculous ulcers associated with exuberant granulations should be lightly touched with a diathermy current. But in my opinion the amount of instrumentation required for such a procedure makes it inadvisable. *Local treatment*

In very severe cases associated with a constant desire to micturate and intense pain, transplantation of the ureters may be carried out. Another procedure recommended is division of the presacral nerves. Before resorting to these measures, the simple expedient of raising the foot-end of the bed may be tried, since the ulcerations in tuberculous cystitis are mainly in the neighbourhood of the trigone. Raising the foot of the bed encourages the collection of urine in the upper part of the bladder and reduces the pressure on the trigone. *Other methods of treatment*

Even when nephrectomy has been carried out, hygienic measures and possibly tuberculin must always be used as ancillary methods of treatment.

5.–NERVOUS DISEASES

140.] The nervous diseases which most commonly affect the functions of the bladder are those of the spinal cord: e.g. tabes dorsalis, disseminated sclerosis, and myelitis. Sudden or gradual and progressive compression of the spinal cord also causes disorder of bladder and sphincter functions. Syringomyelia very rarely does so, and the system degenerations of the cord, such as amyotrophic lateral sclerosis and Friedreich's ataxy, never cause any impairment of these functions. In acute poliomyelitis with severe paralysis of the legs, there may for one or two days be retention of urine which then gives place to normal activity. *Aetiology*

The common symptoms are (i) retention of urine, (ii) hesitancy of micturition with or without dribbling incontinence, (iii) precipitancy of micturition, and (iv) incontinence of urine and the so-called 'reflex micturition'. *Symptoms*

(i) Retention of urine is the immediate result of severe injury to the spinal cord, such as may be associated with fracture-dislocation of the cervical spine and crush fractures of the spine; it may also occur as an episode in the course of tabes dorsalis or any diffuse lesion of the spinal cord. It is common in caisson disease when this affects the spinal cord. *Retention*

(ii) Hesitancy of micturition is an extremely common symptom in tabes dorsalis. The initiation of the act requires effort; once the flow of urine has begun it may cease and a fresh effort be needed to restart it. When all is passed that the patient can voluntarily pass, urine may dribble by drops for some time and involuntarily. *Hesitancy*

Precipitancy (iii) Precipitancy of micturition, at first without and later with incontinence, is the usual disorder of bladder function in chronic diffuse spinal cord lesions such as disseminated sclerosis, and also in slowly progressive compression paraplegia.

Incontinence (iv) Incontinence and 'reflex micturition' ensue after the stage of retention is passed, in total transverse lesions of the cord and acute injury or softening. It also occurs at some stage in the course of chronic diffuse spinal cord disease (disseminated sclerosis) and gradual compression of the cord. The patient loses all control over the sphincters and passes urine involuntarily (and if there be severe sensory loss, unconsciously) whenever a certain stage of distension of the bladder is reached. In these circumstances, the bladder is not completely evacuated, some residual urine always remaining, and therefore it is perhaps not quite accurate to speak of this as 'automatic' or 'reflex' micturition, if by micturition we understand the *emptying* of the bladder. This incontinence is a mutilated fragment of the act of micturition, it is not the complete act performed reflexly and involuntarily. In passive incontinence the bladder does not contract, but simply overflows.

Diagnosis A familiar example of a spinal cord disease producing incontinence is tabes dorsalis. The diagnosis depends primarily upon the clinical examination and the recognition of the signs of this disease. To this may be added, in those rare cases in which clinical evidence is inconclusive, the examination of the blood and cerebrospinal fluid.

It must be remembered, however, that there exists a type of atony of the bladder that has been described fully by Thomson-Walker and by Geraghty and Braasch in which no lesion of the central nervous system can be discovered.

Associated cystitis The commonest change found in the bladder itself in association with disease of the spinal cord is cystitis. Usually infection has been introduced by passage of a catheter, but it occasionally occurs spontaneously through the blood-stream or the kidneys. The advent of cystitis is followed by an increase in the frequency and sensibility of the bladder, which may in turn result in a temporary diminution of the quantity of residual urine. Associated with the cystitis are other changes in the cystoscopic picture which are due to the nervous lesion rather than to the superimposed infection. These changes may be summarized as trabeculation, diminution in sensibility, and relaxation of the sphincter.

Trabeculation The trabeculation that occurs with a nervous lesion is somewhat different from that found with obstruction, the muscular ridges being finer and more evenly set and their branching more regular and orderly. The disposition is also different. In the obstructive bladder the whole organ is affected, but in the atonic bladder trabeculation is more likely to affect the lateral walls and the apex, and to be absent over the region of the trigone. A marked difference also will be found in the neighbourhood of the bladder neck. Not only is there a marked diminution of sensation in this area, but also complete atony of the sphincter.

Treatment The chief item in the treatment of the bladder is the relief of retention.

Since infection is the most serious complication of atony, the greatest care must always be exercised in the passage of a catheter. If catheterization is necessary, it should be carried out at regular intervals, say three times in the twenty-four hours. A soft rubber catheter of large calibre must be selected and must be boiled before use. If infection has occurred, emptying of the bladder must be followed by bladder lavage. Urinary antiseptics should also be taken by the mouth. Concurrently with the care of the bladder suitable treatment of the nervous lesion must be adopted, in the hope that with an improvement of the primary condition the bladder will also recover. In order to maintain muscle tone electrotherapy may be tried, using either an interrupted or a galvanic current.

Presacral neurectomy

A highly successful procedure in many cases is the operation of presacral neurectomy. Division of these nerves removes inhibitory influences working on the weakened detrusor muscle and may result in a restoration of the contractile power of the bladder. It must be borne in mind, however, that the presacral nerve is the motor nerve of the seminal vesicles, and that division will render the patient sterile although not impotent.

During the War when many cases of nervous lesions of the bladder from gunshot wounds were under treatment, an attempt was made to deal with retention by forcible emptying of the bladder by means of abdominal pressure. In certain cases rupture of the bladder was the result. Such treatment is therefore inadvisable, and if the bladder does not regain the power of emptying itself, the only alternative to catheterization is the establishment of a permanent suprapubic drain.

6.–RUPTURE

141.] Rupture may be complete or incomplete, i.e. the outer coat may remain intact or, as most commonly happens, the whole thickness of the vesical wall may be torn. The bladder is usually full at the time of rupture and the injury direct as from a kick, a fall, or being crushed between buffers. In fracture of the pelvis, a splinter of bone may penetrate the bladder. Rupture may also take place from over-distension during a surgical operation or, if the walls be diseased, from forcible attempts to micturate. From the anatomical point of view the rupture may be intra-peritoneal or extra-peritoneal, most commonly the latter.

Symptoms

Shock is present and is more profound when the rupture is associated with other injuries. The patient complains of pain and a great desire to micturate. The pain is often spasmodic and is associated with straining and inability to pass water; the abdomen is rigid and tender on palpation. Although no water has been passed for several hours, the bulkiness corresponding to a distended bladder cannot be felt per rectum but sometimes there is a bulging in the pouch of Douglas. On passing a catheter only a few drops of blood-stained urine are withdrawn or the bladder may be found to be completely empty. When the rupture is extra-peritoneal dullness appears above the pubes. If the rupture is intra-peritoneal the abdomen becomes distended, there may be dullness in the flanks, the patient vomits and gradually there appear signs of peritonitis.

Diagnosis Diagnosis depends on the history of injury, the knowledge that urine has not been passed for some hours previously, the urgent ineffectual desire to micturate and the absence of urine in the bladder when a catheter is passed. The injection of fluids into the bladder in order to ascertain whether a smaller quantity is returned than is introduced is inadvisable, since it carries with it a risk of spreading infection and of increasing the extravasation of fluid. Exploration of the bladder is the only satisfactory method of establishing a precise diagnosis in cases of doubt.

Treatment An exploratory laparotomy should be performed as soon as possible unless the shock is so great that it is thought preferable to allow a few hours for recovery. The whole of the surface of the bladder is carefully examined for signs of injury and when discovered the rupture is sutured with catgut sutures in two layers. In less severe cases drainage can be provided by means of an indwelling catheter, but with extensive lesions suprapubic drainage is preferable. An extra-peritoneal rupture is most usually situated in the anterior surface of the bladder. If extensive extravasation has taken place the cellular tissues must be drained and this measure will always suffice, repair of the actual rent not being essential.

7.–CYSTITIS

Aetiology 142.] Inflammation of the bladder is generally the result of two factors, an invasion by organisms, and a lowering of resistance due perhaps to the presence of a stone or to an obstruction to micturition.

Bacteriology Provided it be healthy, the bladder wall shows a well-marked resistance to infection, and pure cultures of *Bacillus coli* and other bacteria have been injected into it without producing any ill-effects. Many organisms have been found in the urine in cystitis, and in the majority of cases infection is mixed. The commonest organism both in pure and in mixed infections is the *Bacillus coli communis*. Other organisms that may act as primary infecting agents are staphylococci, streptococci, *B. proteus*, gonococci, *B. pyocyaneus* and *B. typhosus*; and in Egypt and elsewhere *Schistosoma haematobium* (see BILHARZIASIS, p. 323). In chronic cases anaerobic organisms are frequently present. The bladder may be infected from the kidney by means of the urine, from the urethra following the introduction of instruments, directly from without as in the case of a suprapubic fistula, or through the blood-stream.

Symptoms The cardinal symptoms of cystitis are frequency and painful micturition associated with changes in the urine. The earliest symptom is usually an increased frequency which may range from every few minutes to every two hours. *Pain* Pain is present in a varying degree either as a scalding pain along the urethra experienced only during micturition, or as an intense pain associated with a great desire to micturate. This pain is felt in the perineum, in the rectum, along the urethra and sometimes down the thighs. Pyuria is always present but pyrexia is a sign of renal rather than of bladder infection.

On examination tenderness is found over the pubes, and sometimes the bladder wall can be felt through the rectum to be thickened and contracted. Cystoscopy is difficult on account of spasm. When it is carried out, the bladder is found to be markedly retracted and the mucous membrane swollen and reddened. In severe cases there may be ulceration, and bleeding is likely to occur during the examination.

Diagnosis

A complete diagnosis involves not only the proof that cystitis is present, but a decision whether it is primary or due to extension from a focus elsewhere in the urinary tract. The commonest situation for such a focus is the renal pelvis and, in the male, the urethra and prostate. Renal infection is associated with symptoms characteristic of a lesion in that area, namely, pain, tenderness and enlargement. The cystoscope assists in establishing the existence of a pyelitis or a pyonephrosis, the mucosa surrounding one of the ureteric orifices being reddened and oedematous. Not only does the orifice show inflammatory changes but the efflux from that side is purulent. In milder cases in which the character of the efflux is doubtful, ureteric catheterization shows that the urine coming from that ureter contains pus cells. Confirmatory evidence of renal trouble may be furnished by intravenous pyelography.

From the clinical point of view, cystitis may be classified as acute, subacute, or chronic, and the treatment will vary according to the stage at which it is started.

Treatment of acute cystitis

In acute cases the patient should be confined to bed, and treatment directed to soothing the inflamed mucosa. A light diet should be given and alcohol forbidden. Diuretics such as Contrexéville, Vitel and Vichy are freely administered, and if the urine is markedly acid, alkalis may be given in addition. Hot baths, two or three times a day, will often bring relief. These may be supplemented by hot fomentations or a hot-water bottle over the pubes and warm rectal douches. When pain is very marked a morphine and belladonna suppository (see p. 384) or a small enema containing 20 to 30 grains of antipyrin should be prescribed.

Urinary antiseptics should not be given until the acute stage has subsided. In cases of coliform bacillus infection alkalis often help, but if the urine is already alkaline on account of ammoniacal decomposition, dilute mineral acids, sodium benzoate, sodium acid phosphate and ammonium chloride are more useful.

Treatment of chronic cystitis

Should the cystitis be of the chronic variety, a very careful search must be instituted to discover whether any contributory cause exists. Of these the commonest are renal suppuration, calculus, diverticulum and prostatic obstruction. A search for tubercle bacilli should be made if no reason can be found for the failure of the cystitis to clear up. In the treatment of chronic cystitis, bladder-lavage plays an important part. This can be carried out either through a catheter or by the

Janet method. The most useful solutions for bladder irrigation are potassium permanganate (1 in 5,000), mercuric oxycyanide (1 in 5,000), mercuric biniodide (1 in 10,000) and silver nitrate (1 in 10,000). Instillations of small quantities of more powerful antiseptic lotions may also prove useful, such as iodoform in sterile liquid paraffin (5 per cent), silver proteinate or the proprietary protargol (2 per cent), picric acid (1 per cent) and silver nitrate (2 per cent).

Operative treatment in the form of drainage is necessary only in cases of fulminating cystitis associated with sloughing of the mucous membrane. Urethral drainage by means of an indwelling catheter, combined with frequent lavage, may however be useful.

Sodium mandelate

An exceedingly useful line of treatment in subacute and acute cases is by sodium mandelate. This has now almost entirely replaced the ketogenic diet treatment previously employed. See the article on COLIFORM BACILLUS INFECTIONS.

Serum and vaccines

Serum and vaccine treatment are on the whole disappointing but are more likely to succeed in the acute than in the chronic case. If a vaccine is given it should be autogenous. If the cystitis is secondary to a lesion in the kidney or the prostate a complete cure will not be effected unless appropriate treatment of these organs is adopted.

8.–SYPHILIS

143.] Syphilis of the bladder is a rare condition. In the secondary stages of syphilis an acute or chronic cystitis may develop, but is usually transitory. Syphilitic lesions of the bladder are usually undiagnosed. They may take the form of gummata which later break down into gummatous ulcers. Another tertiary lesion is the formation of papillomas which are indistinguishable from other papillomas except for the fact that they disappear under anti-syphilitic treatment.

Diagnosis

The diagnosis is made by the examination of urine and the failure to discover organisms that could account for the condition, by the past history of syphilis, by the Wassermann test and, if cystoscopy has been carried out, by the appearance of the lesion. The most useful of all tests, however, is the satisfactory result obtained from antisyphilitic remedies.

9.–EXTROVERSION

(Ectopia vesicae)

144.] In this condition there is a congenital absence of the anterior wall of the bladder; the mucous membrane is exposed and the ureters open on to the surface of the body. Male infants are affected more often than females, but the cause of the arrest in development is unknown. The condition is associated with an open symphysis, wide separation of the hips, and a bending forward of the body to protect the exposed sensitive mucous surface. A suprapubic hernia frequently develops. Life is rendered miserable by the constant escape of urine, and the patient eventually dies of progressive dilatation of the ureters and kidneys, associated with ascending infection. Many patients attain adult life and in some cases carcinoma of the exposed mucous membrane develops.

Treatment

Many ingenious plastic operations have been planned for reconstituting the bladder. Although a few of these have succeeded, they often fail to relieve the patient's condition either because complete closure cannot be effected or else because, even if it is, the absence of sphincter control remains a handicap to the sufferer. The majority of surgeons have therefore abandoned plastic operations in favour of transplantation of the ureters into the rectum, sigmoid flexure or vagina. Of these operations rectal transplantation is the most successful. The rectal mucous membrane readily accommodates itself to its new function of forming a reservoir for the urine, and the patient's life is rendered tolerable. When transplanting ureters into the bowel, three chief factors must be guarded against: stricture at the site of implantation, trauma of the ureter with subsequent sloughing, and ascending infection of the kidney through reflux from the bowel. In order to minimize these risks various techniques have been elaborated by R. C. Coffey, H. J. Stiles and G. Grey Turner, and it is to a great extent through their industry and ingenuity that the operation of transplantation of the ureter has become a practical procedure. In the majority of these techniques only one ureter at a time is transplanted. If a simultaneous transplantation is carried out, the second of Coffey's methods must be employed. In this, ureteric catheters or fine rubber tubes are fastened within the ureter by ligatures which both seal the ureter against intestinal infection and anchor it to the catheter. The catheters are passed through an opening in the mucosa of the bowel at the caudal end of an uncompleted incision. They are brought out through the anus and provide a channel for the escape of urine until the anastomosis is healed. When catheters are not employed the method of anastomosis resembles in its main features that employed in Witzel's gastrotomy, about 1½ inches of ureter being buried in the bowel wall.

Transplantation of ureters

Technique

Mortality

The mortality statistics of the operation in favourable cases are from 13 to 23 per cent. Later deaths are all always due to the same cause, namely, dilatation of the ureters and renal pelves associated with sepsis.

The introduction of intravenous pyelography has enabled a more exact investigation of the kidneys to be carried out in subsequent years, and pyelograms show that transplantation is always followed by some degree of hydro-ureter and hydronephrosis. In spite of this, the misery imposed by ectopia vesicae is so great that the operation is justified, even although it carries with it this risk to the kidneys; for after successful transplantation many patients live for years in great comfort. They have been recorded alive and well fifteen and more years afterwards. Grey Turner recorded the case of a patient who subsequently became the mother of three children.

10.–HERNIA

145.] Bladder hernia is comparatively rare but it may occur when a thin-walled bladder lies in close relation to a weak inguinal or femoral ring. Any cause producing distension or atrophy of the bladder wall and weakening of the inguinal or femoral outlets must be considered a cause of bladder hernia. The signs are those of an inguinal or femoral hernia associated with vesical symptoms. Difficulty in micturition, micturition in two parts, retention and cystitis are all common symptoms. More often than not, however, the condition is only diagnosed during an operation on a hernia, and more especially on an irreducible hernia. The chief danger is that the surgeon may not recognize the nature of the contents of the hernial sac and may either penetrate the bladder or include it within a ligature. If such be the case haemorrhage and strangury will follow the operation and fatal peritonitis is likely to ensue.

Treatment When a correct diagnosis has been reached before or during operation, the treatment is simple. After separating the viscus from the other contents of the hernial sac it is returned to the abdomen and the abdominal wall repaired in the usual manner.

11.–DIVERTICULUM

146.] A diverticulum of the bladder must be distinguished from the smaller pouches and saccules commonly seen in an obstructed bladder. A true diverticulum is much larger and it communicates with the cavity of the bladder by means of a narrower opening. Diverticula may be single or multiple and may be situated in any part of the bladder, but most frequently are in the neighbourhood of the ureteric orifice. They occur more often in men than in women and are generally believed to be caused by a congenital weakness in the musculature of the bladder. Another factor in their production is an increase in intravesical pressure. This probably accounts for their frequency in the male since it is the male who suffers from long-standing obstruction as the result of stricture and prostatic enlargement. A diverticulum situated at the apex of the bladder is due to incomplete closure of the urachus.

Symptoms The symptoms of a diverticulum are usually associated with the symptoms of obstruction, and more often than not with those of cystitis. The symptoms produced by the diverticulum when uncomplicated by cystitis or obstruction are very puzzling. Frequency and difficulty in micturition are probably the commonest, but often no outward signs exist and the diverticulum is discovered accidentally during the examination of the bladder for some other disease. Micturition in two parts has been regarded as symptomatic, but this only occurs when the diverticulum is very large. If infection has occurred the urine passed during the second half of micturition is more purulent than that passed at first.

Diagnosis

A large diverticulum can be felt in the lower part of the abdomen as a tumour which persists after the patient has apparently emptied his bladder. Sometimes the diverticulum can be felt only on bimanual examination. Small diverticula cannot be felt either per abdomen or on rectal examination. The diagnosis is made by cystoscopy, the dark, regular opening of the sac being easily recognized. Its edges are sharply defined, its outline round or oval, and the surrounding bladder wall appears healthy except for the presence of puckers and ridges radiating from the orifices and resembling the folds of peritoneum seen at the neck of a hernia when viewed from within the abdomen.

The size of the orifice bears no relation to the dimensions of the diverticulum. If it is associated with obstruction, trabeculation will be present, and if with infection, the appearances characteristic of cystitis will be added. In order to demonstrate the size of a diverticulum cystography may be carried out. Solutions of potassium iodide and bromide are irritating to the bladder and the best distending media are 5 per cent lipiodol in sterile olive oil or a 5 per cent suspension of silver iodide. A number of radiograms should be taken with the patient in different positions. Plates should also be exposed with the bladder fully distended and after it has been emptied by means of a catheter.

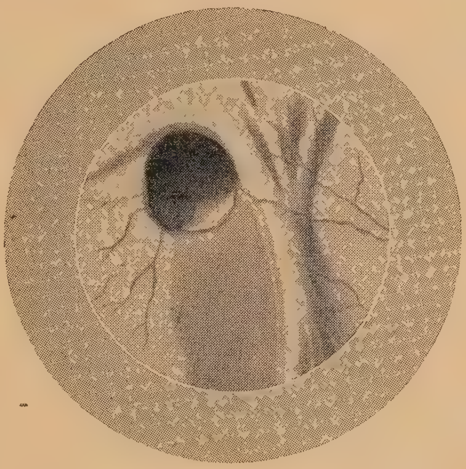

FIG. 68.—Diverticulum of bladder (Thomson-Walker collection)

Treatment

The ideal treatment of bladder diverticulum is excision. Palliative measures, such as lavage or suprapubic drainage, have no material effect and should be adopted only when excision of the diverticulum is out of the question.

Operations

A number of operations have been planned for the removal of a diverticulum, such as excision from outside the bladder, intravesical removal, invagination of the sac and transperitoneal excision. The usual operation is an extra-peritoneal excision through a median suprapubic opening. The operation may be one of the most difficult in surgery owing to the fact that the diverticulum lies deep in the pelvis, is usually adherent to surrounding structures and, more often than not, involves transplantation of the ureter. Nevertheless the results are excellent, and fortunately a prolonged operation on the bladder is likely to cause less shock than an operation on most other abdominal organs.

The intravesical operation is only suitable for small diverticula. It consists of exposing the diverticulum through the bladder, making a circular incision through the mucous membrane and muscular wall a quarter of an inch from the margin of the lip of the opening, and delivering the diverticulum into the bladder. Transperitoneal excision is only suited to diverticula on the upper portion of the bladder.

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BLASTOMYCOSIS

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1. DEFINITION – – – – – – 403
2. BLASTOMYCETIC DERMATITIS – – – 403
3. COCCIDIOIDAL GRANULOMA – – – 405

Reference may also be made to the following title:

FUNGOUS DISEASES

1.–DEFINITION

(*Synonyms.*—Chicago disease; Gilchrist's disease)

Under the name blastomycosis two conditions are usually classified: (1) blastomycetic dermatitis of Gilchrist, and (2) coccidioidal granuloma. Both are caused by fungi which have a resemblance to yeast. In the former, vegetating papilliferous lesions are found in the skin, which is primarily attacked, and sometimes widespread metastatic abscesses in the subcutaneous tissue, bones and internal organs. Coccidioidal granuloma attacks primarily the lungs and other organs, and secondary lesions occur in the skin.

2.–BLASTOMYCETIC DERMATITIS

147.] Blastomycetic dermatitis was first described by T. C. Gilchrist, of the Johns Hopkins Hospital, in 1894; in 1896 a full account of the histo-pathology of the disease and a very complete description of the causal organism known as *Cryptococcus gilchristi* was published in the *Johns Hopkins Reports* and to this account very little of value has been added subsequently. Although the organism is easily cultivated and has been the subject of numerous studies, its natural history remains obscure. *General*

The disease occurs chiefly in the United States of America and is extremely rare elsewhere. It is occasionally seen in India. *Incidence*

The organism The cryptococcus is spherical and resembles a yeast cell surrounded by a doubly refractile capsule; within the capsule is a finely granular protoplasm containing invariably a large vacuole; endospores are never seen. The parasite multiplies by budding; it can be seen in the pus expressed from a cutaneous lesion and in histological sections. In cultures on artificial media long mycelial filaments quickly develop but these are never seen in the parasitic phase.

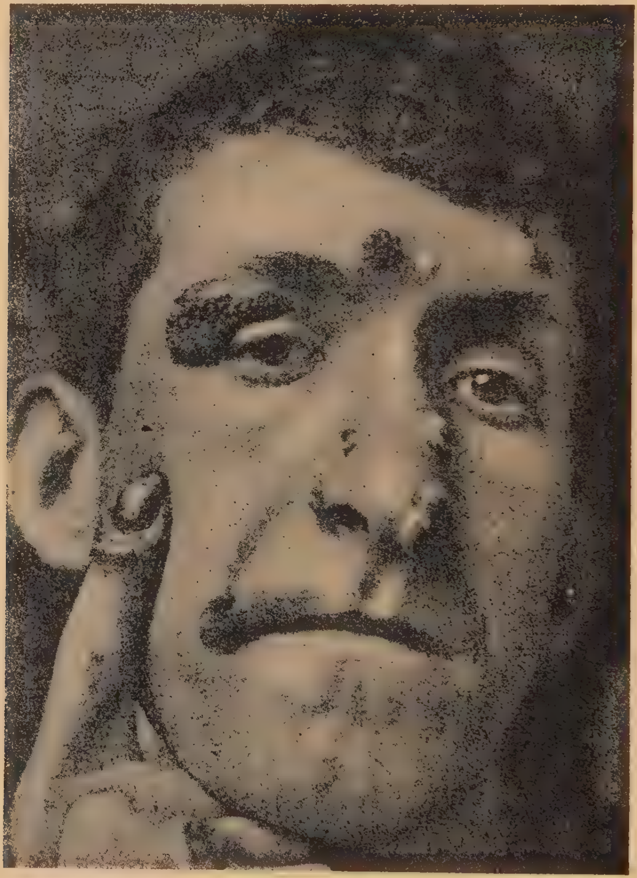

FIG. 69.—Blastomycetic dermatitis

(From *The British Journal of Dermatology and Syphilis*)

Morbid anatomy In the cutaneous lesion the principal changes occur in the epidermis; the epithelium is enormously hypertrophied and irregular prolongations of various shapes and sizes penetrate into the corium. Throughout the changed rete there are a large number of miliary abscesses, the largest just visible to the naked eye. These abscesses contain polymorphonuclear leucocytes, detached epithelial cells, occasional giant cells and parasites. One or more of these may often be found in a histological section of an abscess, some in the process of budding; occasionally a parasite is seen enclosed in a giant cell.

In the corium the changes are also very marked; papillary prolongations of very irregular size and shape extend upwards into the epidermis, sometimes almost to the surface. Miliary abscesses similar to those in the epidermis are present but are fewer in number. Large collections of cells, principally polymorphonuclear leucocytes and endothelial cells, are seen, especially around the vessels.

Clinical picture

The uncovered part of the skin is usually the primary site of infection and the initial lesion is a papillary vegetation; at first a reddish nodule, it extends gradually by a bluish or dark red elevated border surmounted by warty vegetations, to form a plaque of irregular outline. By lateral pressure small beads of pus can be expressed from the interpapillary crevices. There is some tendency to healing in the centre of the lesion while the peripheral extension is taking place.

General dissemination

Blastomycetic dermatitis may be confined to the skin for years or may be followed quite early by systemic infection. In the latter event fresh vegetating lesions appear in the skin on both covered and uncovered parts as well as abscesses in the subcutaneous tissue and tissues generally, no organ being exempt. The subcutaneous lesions break down to form irregular ragged superficial ulcers with purulent bloody discharge. The systemic invasion is accompanied by fever.

Course and prognosis

Blastomycetic dermatitis is normally a chronic infection and often one or a few persistent cutaneous lesions are the only manifestations for months or years. The prognosis is generally good, but in a small proportion of cases early or late systemic infection takes place in the manner already described, and in these the outcome is invariably fatal.

Differential diagnosis

The cutaneous lesion very closely resembles verrucose tuberculosis and may also be mistaken for dermatitis vegetans, syphilis, sporotrichosis, leishmaniasis and epithelioma.

Treatment

In the chronic cutaneous variety of blastomycetic dermatitis iodides in large quantities (20 to 60 grains, three times a day) have proved an almost specific remedy. For the systemic cases no treatment of any value has been found.

3.—COCCIDIOIDAL GRANULOMA

(*Synonyms.*—California disease; coccidioidosis)

148.] This disease is rare and is almost confined to California. The first case was reported in 1890 by Wernicke and Posadas of Buenos Ayres. Rixford and Gilchrist in 1896 described two further cases and named the causal organism *Coccidioides immitis.*

The organism

The causal organism is a yeast-like fungus differing from *Cryptococcus gilchristi* in its larger size and in reproducing itself chiefly by endosporulation. Inside the doubly refractile capsule as many as one hundred endospores are sometimes found. The capsule in time becomes thin at one point and finally ruptures discharging the endospores. The organism grows well on artificial media; hyphae are rapidly produced in culture but are absent in the parasitic phase of the organism.

Pathology Coccidioidal infection may be found in every organ of the body except the intestine. The lesions are similar to those of tuberculosis, but are more acute and have a greater tendency to develop into abscesses.

Incidence Young adult males are generally attacked. The organism generally gains entrance to the body by the respiratory tract.

Clinical picture The lesions consist of abscesses in the subcutaneous tissue and bones, invasion of the lungs, meninges and other organs, and enlargement of glands. Acute systemic infection sometimes gives rise at first to a prolonged fever without demonstrable lesions. As in blastomycetic dermatitis, the cutaneous lesions are usually found on the exposed parts. They consist of shallow ulcers, sinuses connected with subcutaneous abscesses or infected lymph glands, indolent swellings resembling syphilitic gummata, and, rarely, warty lesions like those of blastomycetic dermatitis.

Prognosis Acute and chronic cases occur, both being almost invariably fatal.

Treatment Although many drugs have been tried none have proved to have any real value in the treatment of coccidioidal granuloma. Fresh air, sunshine and nourishing diet are necessary to prolong life.

Surgery According to Howard Morrow seven cases have been cured by early amputation of an affected limb; it therefore appears advisable to resort to surgical measures in those cases in which the disease seems to be limited to an extremity.

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BLEPHARITIS

See EYELIDS, INJURIES AND DISEASES

BLINDNESS

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BRAIN: VASCULAR DISORDERS
CATARACT
CEREBRO-RETINAL SYNDROMES
CONJUNCTIVA, INJURIES AND DISEASES
CORNEA, INJURIES AND DISEASES
CRANIAL NERVE AFFECTIONS
EYELIDS, INJURIES AND DISEASES
GLAUCOMA
PAPILLOEDEMA
RETINA DISEASES
TRACHOMA
UVEAL TRACT DISEASES

1.–DEFINITION AND CLASSIFICATION

149.] Blindness in a strictly scientific sense should signify that there is no perception of light in either eye, but those in whom sight is so defective as to prevent them from earning a living are regarded as blind. In Great Britain the Blind Persons Act 1920 defined blindness as 'Too blind to perform any work for which eyesight is essential'; this means any work, and not necessarily the affected individual's own occupation.

The highest incidence of blindness occurs in the first ten years of life, from ophthalmia neonatorum and injuries and diseases of the cornea. This is of great importance in preventive work. Ophthalmia neonatorum, syphilis, phlyctenular keratitis, trachoma, myopia, glaucoma and injuries from industrial accidents and in games and sport are among the common causes of blindness.

Group 1. The vision is below 3/60.

Group 2. The vision is 3/60 but less than 6/60 and the patient is regarded as blind if the visual fields are considerably contracted.

Group 3. The vision is 6/60 or better. The patient is not regarded as blind unless the field is markedly contracted in the greater part of its extent and particularly in its lower half.

Patients suffering from homonymous or bitemporal hemianopia with 6/18 visual acuity or better are not regarded as blind.

Blindness in children

In the Education Act 1921 a child who is unable to read ordinary school books is regarded as blind. Children are sent to a 'blind school' if the vision is less than 6/60, and also when it is as good as 6/60 when this is accompanied by nystagmus, defects in the media and tunics of the eyes, contracted fields and ocular disease liable to progress. Schools for partially sighted children are provided for cases of myopia with fundus changes and showing rapid progress, and for children whose corrected vision is 6/24 or worse.

There are slight variations in the standards set by other nations for 'complete' and 'incomplete' blindness in respect of adults and children, and for statistical purposes there is need for international uniformity.

Hereditary diseases

Hereditary ocular diseases are responsible for cases of complete blindness, incomplete blindness, and amblyopia; although in a large proportion of cases these diseases cause only partial blindness, it is thought proper to include them in the causes of blindness.

Classification

In this article blindness has been classified according to certain pathological groups in which disease may manifest itself. Any of these groups may overlap, or any one may present features of several groups; for instance glioma retinae is a congenital tumour in which hereditary and familial influences play a prominent part. The pathology of certain ocular conditions, such as glaucoma and myopia, is still obscure and hence these and some others will be considered apart from those diseases which fall into the more common pathological groups.

2.–CONGENITAL DEFECTS

150.] A number of congenital defects may cause serious impairment of vision, or the arrested structural development and gross malformation may render the eye, as the sensory end-organ of vision, ineffective and useless.

(1)—The Globe

Anophthalmos

Anophthalmos is a condition in which the optic vesicle has failed to bud off from the anterior cerebral vesicle.

Cystic eyeball

Congenital cystic eyeball represents an arrest of development at the stage when the primary optic vesicle has formed. It is lined by embryonic retina and surrounded by fibrous tissue into which muscles are inserted.

Cyclopia

Cyclopia (synophthalmia) is produced by a failure of the optic vesicles to diverge laterally from each other after budding off from the neural tube. The two vesicles lie opposed to each other in the mid-line and become surrounded by mesoderm which forms the tunics of one eye and encloses two retinae and two lenses.

Microphthalmos

Microphthalmos with congenital cyst is associated with a failure of the foetal ocular cleft in the secondary optic vesicle to close. There is union between the mesoblastic tissues inside the secondary optic vesicle and those outside it giving rise to a coloboma of the retina and optic nerve.

Buphthalmos is a congenital type of glaucoma (see p. 448).

(2)—Optic Nerve

Absence of optic nerve fibres.—The axis cylinders of the optic nerve fibres may fail to grow from the ganglion cells into the neural tube. This defect is sometimes associated with anencephaly and defective development of the occipital lobes.

(3)—Choroid, Retina and Iris

Coloboma

Congenital coloboma of the macula may be familial and in some instances is inflammatory in origin.

Coloboma of the choroid and retina is due to defective closure of the foetal ocular cleft. The coloboma presents a glistening white comet-shaped area with its apex towards the optic disc in the lower part of the fundus. The optic disc is in some cases involved in the coloboma. The periphery of the coloboma is fringed with flecks of pigment. Retinal and a few choroidal vessels traverse the coloboma but the vessels are mainly direct from the posterior ciliary arteries. Central vision is defective and there is a corresponding scotoma. (See Plate III, A.)

Congenital retinal detachment, described by some authorities, may in some instances be secondary to intra-uterine affection of the uveal tract.

Albinism

Albinism is due to defective development of intra-ocular pigment, particularly that from the outer layer of the secondary optic vesicle which forms the retinal pigment epithelium and its forward prolongation on the ciliary body and posterior surface of the iris. Pigment is also absent from the uveal tract and indeed from the rest of the body. The iris looks pink and the patient suffers from dazzling. Nystagmus, photophobia, a refractive error, myopia and astigmatism, and rarely hypermetropia and convergent strabismus are present. The condition is hereditary (see article on ALBINISM, Vol. I, p. 271). Vision is in many cases very defective.

Treatment consists in correcting the refractive error by glasses which should be tinted, Crookes A2 or B1 being suitable.

Nyctalopia and hemeralopia

Nyctalopia.—Night-vision is a condition in which the sight is better at night or in semi-darkness than by daylight.

Hemeralopia.—Day-vision or night-blindness. The sight is good by day or in a strong light, but fails at night.

Through misuse in modern times these two words, nyctalopia and hemeralopia, have come to mean the precise opposite to what their derivation from the Greek implies. The proper derivation of nyctalopia is νύξ = night; ἀλαός = blind; ὤψ = eye, meaning night-blindness. Hemeralopia is derived from ἡμέρα = day; ἀλαός = blind; ὤψ = eye, meaning day-blindness. Gould's Medical Dictionary, edited by Scott, 2nd edition 1928, says 'that an attempt to reinstate the ancient usage of these words can only result in confusion and they should therefore never be used'.

Nyctalopia is due to defective development of the cones. It is associated in some cases with nystagmus and mental deficiency and is familial and hereditary. The optic disc is pale and white dots and pigment deposits are present at the macula.

Night-blindness is a congenital defect associated with retinitis punctata albescens, which may occur in families affected with retinitis pigmentosa. It is characterized by round, oval, or dumb-bell shaped white dots scattered throughout the fundus deep to the retinal vessels and not involving the macula. These spots never change their appearance. Several members of a family may be affected and consanguinity plays a part. Congenital night-blindness of an hereditary character may be present and persist throughout life in some cases in which there is no ophthalmoscopic evidence of disease.

Uveal tract

Choroideremia (absence of the choroid) and *aniridia* (absence of the iris) are associated with defective vision. A *persistent pupillary membrane* which is dense may by occluding the pupil seriously impair sight.

Corectopia

Corectopia (abnormal position of the pupil) may cause defective vision through failure of the rays of light from an object to pass through the centre of the lens.

Iridocyclitis

Iridocyclitis and *uveitis* in utero are generally due to syphilis. Iris bombé, occlusio pupillae, and organized inflammatory cyclitic membrane and retinal detachment are among the complications.

(4)—Lens, Vitreous and Cornea

Lens

Ectopia lentis, *lenticonus* and *coloboma lentis* produce refractive problems with impairment of vision.

Polar, capsular, lamellar, nuclear and cortical cataracts impair visual acuity (see Cataract, p. 448).

Vitreous

Vision may be affected by the persistence of an hyaloid artery sheath associated with defects in the posterior capsule and cortex of the lens.

Cornea

Opacities in the cornea due to injuries during delivery involve the deeper layers of the substantia propria and may be associated with rupture of Descemet's membrane. Involvement of the centre of the cornea by an opaque linear scar in its substance damages vision.

Keratoconus

Keratoconus is due to a congenital weakness of the cornea which often does not manifest itself until after puberty. The apex of the cone is slightly below the centre of the cornea and is its thinnest part. Vision is defective on account of irregular astigmatism. At a later stage more or less parallel striae appear near the apex, anastomosing at acute angles, and also discrete opacities which become confluent. A brown ring may form in the epithelium surrounding the cone. Ruptures in Descemet's membrane sometimes occur.

If vision cannot be appreciably improved by glasses contact lenses should be tried, and if tolerated will be beneficial.

Anterior staphyloma

Anterior staphyloma is secondary to intra-uterine perforation of the cornea or adhesion between the iris and the posterior corneal surface following anterior uveitis. Vision is seriously impaired, blindness ultimately supervenes and excision becomes necessary on account of pain.

Dermoid

The cornea is sometimes replaced by a rare congenital neoplasm, a dermo-fibro-lipoma.

(5)—The Lids

Total *symblepharon* and *ankyloblepharon* cover the eyeball completely. An attempt should be made to open the lids surgically along the proper line of cleavage and by plastic reconstruction to effect a palpebral fissure. Some cases of ankyloblepharon are associated with cryptophthalmia, congenital cystic globe, and anophthalmos.

(6)—Congenital Neoplasms of Orbit

Certain congenital neoplasms in the orbit, such as *blastocytoma* and *teratoma*, damage the eye and the optic nerve. Exenteration of the orbit is necessary.

3.–TRAUMA

(1)—Injuries to Cornea, Sclera, Lens and Uvea

Cornea 151.] The corneal tissue deep to the epithelium if damaged severely is in the course of time replaced by opaque fibrous tissue covered by epithelium. If this occurs over the pupillary area vision is spoiled. Chemical burns and infected abrasions are the common cause of this.

Treatment consists in cleansing the injured area with irrigations of warm physiological saline, instilling drops of sterile liquid paraffin, dilating the pupil with atropine and tying up the eye with a pad and bandage. Cell debris and necrotic tissue should be carefully removed and, if the damaged area becomes infected, carbolization or chauffage may be necessary.

Sometimes it is possible to improve the vision at a later date by performing optical iridectomy under a clear piece of cornea, if such is available. Corneal grafting may properly be considered when both eyes are damaged or when one damaged eye alone remains. It is of course important in this procedure for the tissues behind the opaque cornea to be in a satisfactory condition.

Sclera Injuries of the eye from blunt objects may result in rupture of the globe. The commonest site of this is concentric with, and 3 mm. behind, the limbus in the upper nasal quadrant. This injury is commonly effected by a blow from a closed fist coming up from the lower temporal quadrant and compressing the globe against the upper and inner angle of the orbit. Subconjunctival dislocation of the lens, prolapse of the uveal tract and severe intra-ocular haemorrhage and intra-ocular subluxation of the lens are the commonest complications.

In cases in which the overlying conjunctiva is intact and there is no prolapse of the uveal tract the eye is best treated with atropine and a firm pad and bandage, the patient remaining in bed until secure healing has been established.

Lens If the lens is dislocated into the subconjunctival tissues and there is no prolapse of the uvea it is best left untouched surgically until the scleral wound has healed.

Uvea Prolapse of the uvea should be dealt with by reflecting a conjunctival flap, if possible inserting sutures in the sclera, cutting away all prolapsed and damaged tissue, replacing the cut edges of the uvea and closing the wound over it with the conjunctival flap. Vitreous loss is a likely complication during this procedure.

(2)—Perforating Wounds

The prognosis of perforating injuries of the eye depends upon infection, the site of the wound, the presence of an intra-ocular foreign body and the amount of damage done to the lens, retina and uveal tract.

Wounds in the ciliary region are particularly dangerous in view of the risk of sympathetic ophthalmitis which is attached to them (see below). The impaction of strands of lens capsule and uveal tract in an infected wound favours this disaster in susceptible persons and particularly in children and old women.

Investigations should be directed towards ascertaining the limits of the wound, the state of the lens, and the presence or absence of an intra-ocular foreign body; if the lens is undamaged this last may be discovered by ophthalmoscopic examination, but when the lens is damaged, rendering ophthalmoscopic examination difficult, an X-ray examination is called for and will reveal the presence of a foreign body if it is metallic. In the case of a retained intra-ocular foreign body much will depend on its magnetic properties and the length of time it has been in the eye.

Treatment

The principles of treatment are careful cleansing of the site of the wound, the preparation of a conjunctival flap to cover it in cases in which the site and size of the wound make this necessary, abscission of prolapsed intra-ocular tissue and careful replacement of any lens capsule or uveal tract.

Use of magnet

In the case of magnetic intra-ocular foreign bodies a giant magnet, the Mellinger or Haab, is used to draw the foreign body forwards into the anterior chamber and from there it is removed by a small hand magnet through a corneal incision. Atropine and a pad and bandage are applied. In drawing the foreign body forwards from the vitreous chamber great care and skill are required to pilot it through the suspensory ligament into the posterior chamber and thence through the pupillary aperture into the anterior chamber. The presence of an anterior chamber is essential for the successful removal of an intra-ocular foreign body by the anterior route. Removal by the posterior route, incising the sclera over the site of the foreign body, is more dangerous. Large intra-ocular foreign bodies cause considerable damage and the eye seldom recovers. It may be very difficult or impossible to remove an intra-ocular foreign body which has been impacted for some time and has become surrounded by fibrous tissue.

Complications

In such cases as these vision may become seriously impaired from intra-ocular inflammation and haemorrhage, traumatic cataract, retinitis proliferans and detachment of the retina. Panophthalmitis may destroy the injured eye in a few days. Siderosis bulbi is a degenerative change occurring in cases of retention of an intra-ocular foreign body, and is due to the passage of iron in solution into the tissues of the eye.

(3)—Sympathetic Ophthalmitis

Sympathetic ophthalmitis is an iridocyclitis which arises after a perforating wound. The physical signs in the injured or exciting eye are followed after an interval varying from four weeks to forty years by changes in the other or sympathizing eye. It is more liable to occur in the case of infected wounds in the ciliary region, particularly when the lens capsule or iris is impacted in the wound.

Aetiology

There is some experimental evidence in support of the view that some persons are more susceptible than others to sympathetic ophthalmitis; some of these persons may show a positive reaction to intradermal injections of a suspension of uveal pigment. It has been suggested that sympathetic ophthalmitis is an allergic disease, the tissues of the uveal tract being sensitized to the presence of uveal pigment or substances elaborated as the result of pigmentary disturbance in the uveal tract. Certain facts, however, are incompatible with this theory.

According to the infective theory this disease is caused by a filterable virus with specific selectivity for the tissues of the uveal tract of the other eye, the virus being transferred by the optic nerves and chiasma. It is probable that certain allergic phenomena and the presence of an infective agent have a complementary action.

Symptoms

Prodromal symptoms are sensitiveness to light and transient indistinctness of objects. Slight ciliary injection and tenderness, lachrymation and keratinous precipitates, and vitreous opacities are important physical signs. The vision is often ultimately more damaged in the sympathizing eye than in the exciting eye. The disease is characterized by the formation of much plastic exudate in the circumlental space. Children are particularly susceptible.

Treatment

Prophylactic treatment consists in careful toilet of the perforating wound. During the post-operative period a daily examination of the eye for the presence of punctate precipitates on the posterior surface of the cornea should be made. If during the fourteen days after the injury the injured eye shows well-marked ciliary injection, punctate precipitates, an aqueous flare when examined by the slit-lamp, tenderness on palpation over the ciliary region, and no signs that the inflammation initiated by the trauma and subsequent surgical procedures is subsiding, it should be excised. The uninjured eye is safe from sympathetic ophthalmitis if it is free of all signs of inflammation when the injured eye is removed.

Injections of neoarsphenamine (neosalvarsan) are alleged to be of prophylactic and therapeutic value, but the evidence in favour of this is difficult to assess.

If suppuration occurs in the injured eye sympathetic ophthalmitis is said never to happen. If ciliary injection and punctate precipitates appear in the sympathizing eye the exciting eye should be excised immediately. There is no doubt that this ameliorates the course of the disease in the sympathizing eye. If the disease is of long standing and the vision is better in the exciting than in the sympathizing eye the exciting eye should not be excised.

(4)—Tears and Displacements

Severe damage to vision may follow tears or displacements of certain intra-ocular structures.

Iridodialysis

Certain concussion injuries may lead to the formation of a tear through the iris root causing its separation from the ciliary body. The shape of the pupil is altered according to the size and site of the iridodialysis. In severe cases the entire iris may be torn away or an extensively separated part may hang down and occlude the pupillary area.

Treatment

In some severe cases attempts have been made to suture the iris root back into place by making a keratome section at the limbus, seizing the iris root with forceps and transfixing it with a mattress suture of fine silk which is brought out through the wound and anchored so that the iris root is held in place in the filtration angle.

Choroidal tears

A tear in the choroid at the macula may damage some of the outer layers of the retina and spoil central vision. The tear is usually concentric with the temporal margin of the optic disc and is at first fringed with blood and later with pigment. The retinal vessels frequently traverse it quite undamaged.

Subluxation of the lens

Following injuries by blunt objects the suspensory ligament may be ruptured and the lens dislocated. Dislocation may amount to the lens entering the anterior chamber, the vitreous or the subconjunctival tissues through a rupture of the sclera. Tilting and displacements in various directions in the circumlental space may occur and produce a considerable degree of astigmatism.

Of the remote sequelae of subluxation of the lens, iridocyclitis and secondary glaucoma are of serious consequence. The lens becomes opaque in the majority of cases.

Treatment

If the lens is displaced into the anterior chamber it should be removed as soon as possible. Displacement beneath the conjunctiva through a scleral rupture is best left alone. Absorption of the lens takes place in a number of such cases; if this does not happen, the lens can be needled at a later date when the scleral wound is closed.

Intracapsular or scoop extraction of the lens may be attempted in some selected cases of partial rupture of the suspensory ligament with dislocation of the lens and in which glasses fail to improve the visual acuity. Loss of vitreous often accompanies these procedures. Cyclodialysis or the trephine operation may be necessary for glaucoma which is liable to occur.

(5)—Trauma of Lens and Vitreous

Traumatic cataract

Traumatic cataract (see also p. 449) is characterized by a rosette-shaped opacity in the posterior cortex. Later the entire lens becomes opaque in the majority of cases. A curette evacuation of the opaque lens substance is indicated in young adults and persons up to forty years of age. In children a discission operation of the opaque lens is all that is necessary. In elderly persons the classical extraction operation is indicated in suitable cases.

Other causes of cataract

Cataract may also be caused by injury from lightning, high-tension electric charges, X-rays, radium, and intensive heat from furnaces. In the case of cataract produced by X-rays and radium there is a latent period between irradiation therapy and the onset of the opacities in the posterior lens cortex varying from two to eight years.

Extraction of the cataract leads to restoration of vision provided the retina and optic nerve are healthy.

Trauma of vitreous

Following a blow, the vitreous chamber may fill with blood. The red reflex is dull. Absorption may take place. Retinitis proliferans from organization of the clot is a complication which may be followed by retinal detachment and loss of sight. Liquefaction of the vitreous may be caused by traumatic uveitis.

(6)—Trauma of Retina

Commotio retinae

Commotio retinae.—Oedema at the macula may follow a concussion injury to the eye. A grey discoloration in the fundus around the macula is attributed to oedema. There is a central scotoma and central vision is very defective. The oedema subsides in the course of three or four days and vision may be recovered in a number of instances. In some cases, however, a central scotoma persists and pigmentary changes appear later at the macula. The formation of a hole at the macula is preceded by the presence of cystic degeneration in which the spaces are filled with oedema fluid, and eventually rupture. The edges of the hole are sharply defined and its floor has a bright crimson-red appearance with stippling of its surface.

Treatment

Rest in bed and the exclusion of light is necessary for four or five days after the injury. A guarded prognosis should be made in such cases. Haemorrhages at the macula, and in the interretinal space and the choroid at this site may seriously spoil vision.

Detachment of retina

Detachment of the retina is sometimes caused by trauma. A tear is evident in many of these cases; this may take the form of an anterior retinal dialysis at the ora serrata, round, horseshoe- and arrow-shaped tears and radial splits. The majority of tears are in front of the equator. They are sometimes multiple. The detached area of retina has a greyish reflex, the branches of the retinal vessels appear darker than normal and the retina has wave-like undulations. A tear or hole is marked by the red reflex from the choroid showing through. When it is present in the area of retinal detachment this reflex affords a marked contrast to the grey reflex of the adjacent retina (see Fig. 70).

A vitreous haemorrhage may be present if a branch of a retinal vessel is torn across.

Treatment

The treatment is operative. Accurate localization of the retinal tear is essential. The conjunctiva is reflected from the sclera over the site of the hole and the detached retina. The sclera at this site is treated by the application of a diathermy electrode (surgical diathermy) with a view to

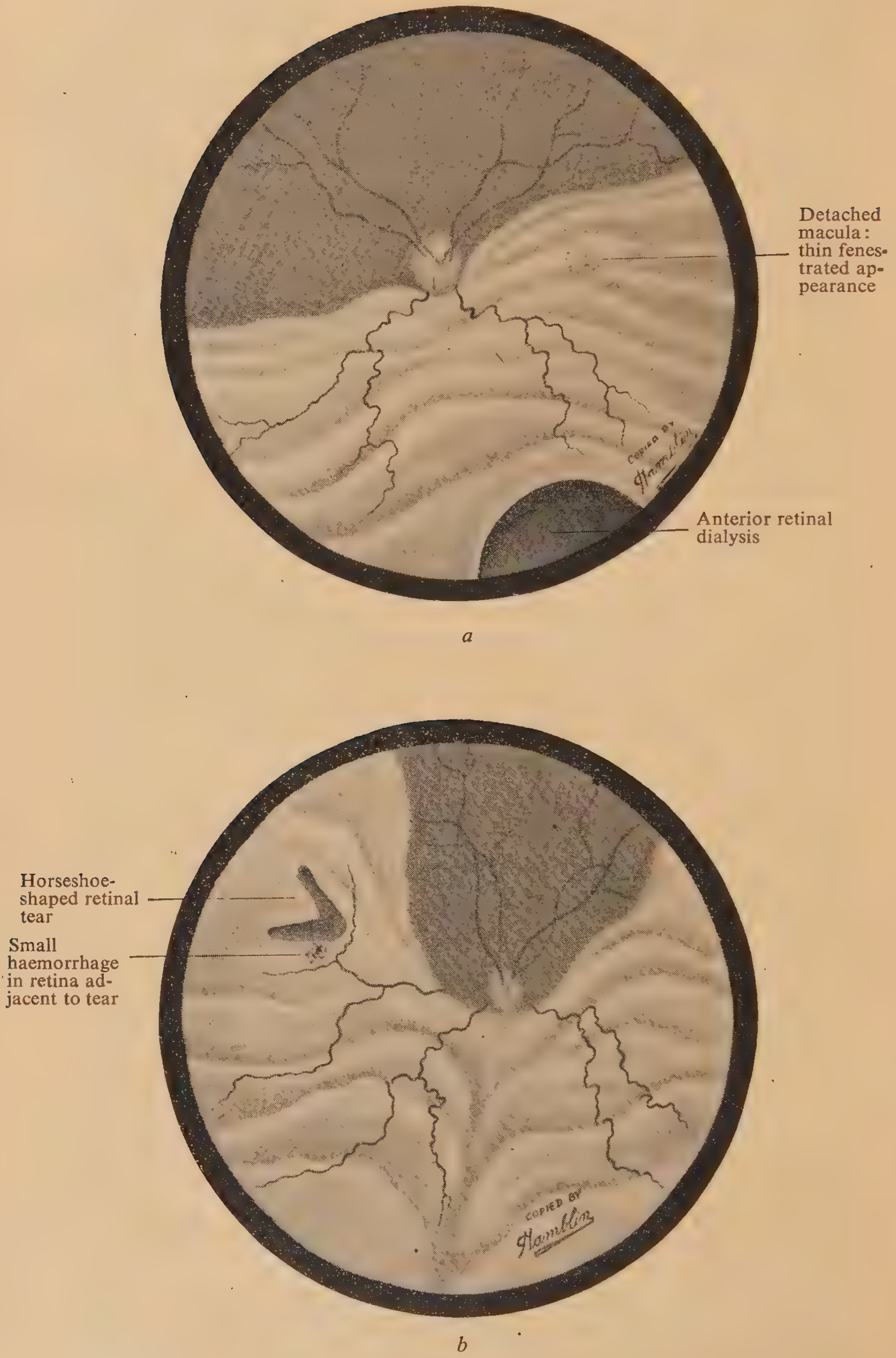

Detached macula: thin fenestrated appearance
Anterior retinal dialysis
COPIED BY Hamblin
a
Horseshoe-shaped retinal tear
Small haemorrhage in retina adjacent to tear
COPIED BY Hamblin
b

FIG. 70 *a* and *b*.—Retinal detachment

inducing choroido-retinitis in the vicinity of the retinal tear. A current of 65 to 70 milliamperes for seven seconds is the average used in the surface diathermy technique of Larsson. The sclera is trephined over the site of the retinal detachment, and the interretinal fluid evacuated by puncturing the choroid. The patient is nursed so that the trephine hole in the sclera is in the most dependent part for drainage of the interretinal fluid and so that gravity may assist the apposition of the detached area of retina to the choroid.

(7)—Other Types of Trauma

Snow blindness

Snow blindness is characterized by photophobia, blepharospasm, hyperaemia, increased conjunctival secretion and sometimes erosion of, or bulla formation on, the cornea. The symptoms develop several hours after the exposure. Light rich in ultra-violet rays such as is reflected from snow is blamed for this condition.

Similar symptoms and signs occur in persons exposed to arc lights, or employed in electric welding.

Electric amblyopia

Exposure to an intense short-circuit flash produces electric amblyopia —i.e. conjunctival injection, blepharospasm, photophobia, headache and diminished vision due to a temporary incomplete central scotoma and contracted fields. Recovery takes place in a number of cases in three or four weeks, but in some the symptoms persist for three or four months.

Eclipse blindness

Serious damage which may be permanent in some instances is done to the central parts of the retina by viewing an eclipse with the eyes unprotected by dark glasses. The visual symptoms come on after an interval varying from a few hours to several days. A partial central scotoma which is more complete for colours is evident. Metamorphopsia may be permanent. Optic atrophy is reported in some cases. The prospects as regards recovery are on the whole good.

Lightning

In some recorded cases organic damage has followed exposure to a lightning flash. Lens opacities, corneal striae and optic atrophy are described.

Gases

A troublesome keratitis recurs some years after exposure in warfare to mustard gas, and spoils vision. The irregularities in the calibre of conjunctival vessels at the limbus are characteristic. Keratitis has also been reported after exposure to sewer gas.

Radium

Radium, applied in massive doses near the eye, has been responsible for corneal necrosis. Cataract, retinitis simulating retinitis circinata, and optic atrophy have also followed the employment of large doses of radium.

Occupational blindness

A number of occupations cause serious damage to sight, apart from those in which injuries to the eyes of workmen may arise from flying particles. Furnace workers, puddlers, casters and glass-blowers are subject to a characteristic type of cataract. Straw-hat makers, caisson workers and oyster openers are liable to keratitis. Corneal opacities are seen in nitronaphthalene and aniline workers.

Wounds The optic nerve may be torn at the optic foramen or in the optic canal by fractures involving the anterior cranial fossa, by perforating wounds from bullets and other missiles.

Haemorrhage Haemorrhage into the orbit and optic nerve sheaths may damage the optic nerve by compression.

4.–INFLAMMATION

152.] Minute inflammatory lesions occurring in tissues along the visual axis, at the macula, and in the papillo-macular bundle of nerve fibres may cause serious and permanent damage to vision. Alterations in the transparency of the media and damage to important nervous structures by oedema, exudate, defective nutrition, toxins and subsequent fibrosis are among the chief ravages of inflammation in the eye.

Origin of infections Infection of an eye may occur from exogenous sources, through the blood-stream and by a spread from a neighbouring inflammatory focus such as nasal sinusitis and lupus of the face. Infection in utero is through the maternal blood-stream and the placental site or through minute holes in the membranes whence gonococci gain entrance to the liquor amnii. Micro-organisms, pyogenic and specific, toxins, viruses and poisonous proteins will produce inflammatory lesions in the vascular tissues and the cornea of the normal eye; and in certain cases in which there is a specific sensitivity of part of the eye, such as the uveal tract, to blood-borne infection from some latent focus that escapes detection in clinical examination, inflammatory lesions may also occur.

(1)—Inflammation of Conjunctiva

(*a*) *Ophthalmia neonatorum*

Ophthalmia neonatorum is a muco-purulent or purulent conjunctivitis affecting the new-born, due to the gonococcus (60 to 70 per cent), streptococcus, pneumococcus, *Bacillus coli*, and other micro-organisms. It is most destructive to vision if the corneal epithelium is damaged by a minute scratch or abrasion, causing infected corneal ulcers with hypopyon; such ulcers may perforate and result in prolapse of the iris, iritis, anterior polar cataract, and loss of the eye from panophthalmitis. Late *Sequelae* sequelae are dense opaque corneal nebulae and anterior staphyloma in cases in which the iris has become adherent to the back of the cornea and the filtration angle is occluded. The development of macular fixation during the first six weeks of life may be seriously impaired by the corneal opacities and nystagmus may become manifest and persist through life.

In a home for blind infants Harman has found that 50 per cent of cases were due to ophthalmia neonatorum. Statistics of children of school age show that 20 to 30 per cent of blindness is due to this disease. Also it accounts for 7 to 8 per cent of all blind people. It is probable that the incidence of the disease has not lessened but owing to prompt and efficient therapeutic measures blindness has been reduced.

Prophylaxis Prevention is effective in a number of cases by swabbing the lid margins and adjacent skin with sterile lint soaked in mercuric chloride solution (1 in 1,000), using separate pieces for each eyelid, as soon as the head is born, and then irrigating the conjunctival sacs with boric acid lotion. One drop of 1 per cent silver nitrate solution should be instilled into the conjunctival sacs if there is any suspicion of infection in the maternal passages. It is important that the water in which the baby is bathed after birth should not enter the eyes. Careful co-operation between the ante-natal and V.D. clinics and the obstetrician or midwife is effective in preventing a number of cases.

The Public Health of England Statutory Rule 971, 1926, has made ophthalmia neonatorum notifiable, the disease being defined as a 'purulent discharge from the eyes of an infant commencing within twenty-one days of birth'. On the form must be noted the date of birth, the name and address of the parent or other person in charge of the infant and the date of onset of the disease. The form is sent without delay to the M.O.H. of the district within which the infant is being attended. Notification is not required when the infant is an inmate of any building, ship, vessel, boat, tent, van, shed or similar structure belonging to H.M. the King.

A watery discharge beginning on the second or third day after birth should arouse suspicion. Later the conjunctiva becomes infected and oedematous, the lids swollen and dusky red and the conjunctival sac full of muco-purulent or purulent discharge which may spurt out on separating the lid margins.

Treatment

Treatment aims at mechanical cleansing of the conjunctival sac, protection of the cornea in the affected eye from abrasion, and of the other eye if unaffected. A Bullar's shield should be carefully applied over the unaffected eye.

Frequent irrigation, once or twice hourly as required, with warm eusol (1 in 10) followed by the instillation of acriflavine (1 part in 1,500 parts of sterile liquid paraffin) is efficacious. If the cornea becomes infiltrated atropine and heat should be applied.

At a later date some vision may be restored in cases of leucoma by a carefully planned optical iridectomy or corneal grafting, but the results of these procedures are often disappointing.

Purulent conjunctivitis in adults

Purulent conjunctivitis in adults due to gonococcus presents similar problems to those described in ophthalmia neonatorum. Application of silver nitrate (1 per cent) to the palpebral conjunctiva followed by irrigations with warm physiological saline and an ointment of mercuric oxycyanide (1 part in 5,000 parts of white soft paraffin) placed in the conjunctival sac and along the lid margins at night time should be used.

(*b*) *Trachoma*

Trachoma is a chronic conjunctivitis characterized by the formation in the upper palpebral conjunctiva and fornix of follicles, some of which rupture and produce scarring. The visual acuity may be considerably reduced by the extension of chronic inflammatory cells and newly-formed vessels into the cornea between the epithelium and Bowman's membrane, so-called pannus, and by corneal ulceration and subsequent scarring from inverted lashes which rub the cornea (trichiasis). The disease is bilateral and contagious in the acute stages. In England it is mainly confined to the alien population of large cities, who are living in poor hygienic conditions; the Irish and Jews are particularly affected. Sporadic cases occasionally occur. The disease is more prevalent in Egypt, Palestine, India and Central Europe. In the late stages scarring and distortion of the lids and their margins, thickening and epidermoid characters of the palpebral conjunctiva, and hyaline degeneration of the tarsal plate are evident.

Aetiology The aetiology of trachoma is still obscure. Research work is now directed towards isolating a virus.

Treatment In communities where trachoma is rife, improvement of hygienic conditions, cleanliness and the routine use of zinc sulphate drops (0·5 per cent) have had some good prophylactic effect. In most cases prompt and vigorous treatment of the disease in the early stages is the only hope of arresting its progress and conserving useful vision.

Thorough cleansing of the conjunctival sac with mild antiseptic or saline irrigations followed by the instillation of 1 per cent pantocain, and rubbing the affected palpebral conjunctiva with a copper sulphate stick once daily for several weeks, and then changing to silver nitrate should be tried. If there is much discharge frequent irrigations are necessary and some mild antiseptic ointment should be smeared along the lid margins at night time. Expression of the follicles is recommended by some authorities and condemned by others. *Grafting* Some surgeons excise the affected area of conjunctiva and replace it with a buccal mucous membrane graft. Partial or complete excision of the tarsal plate of the upper lid and plastic operations for the correction of trichiasis are sometimes necessary in long-standing cases. See also TRACHOMA.

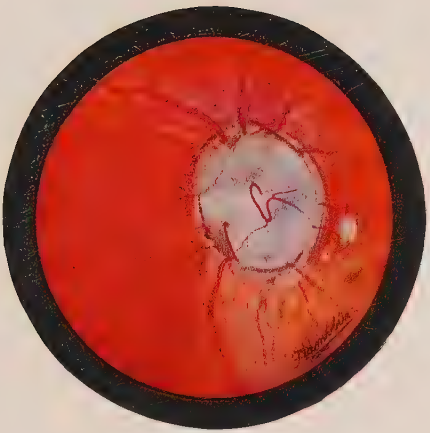
(*c*) *Pemphigus*

Pemphigus is a rare affection of the conjunctiva occurring in elderly persons and producing 'essential shrinkage' of this tissue, superficial corneal opacities and vascularization leading to considerable loss of vision. It is very resistant to any form of treatment. Injections of arsenical preparations, the application of unscreened radium, mucous membrane grafts, and extracts of Harderian gland have received trials but without appreciable success.

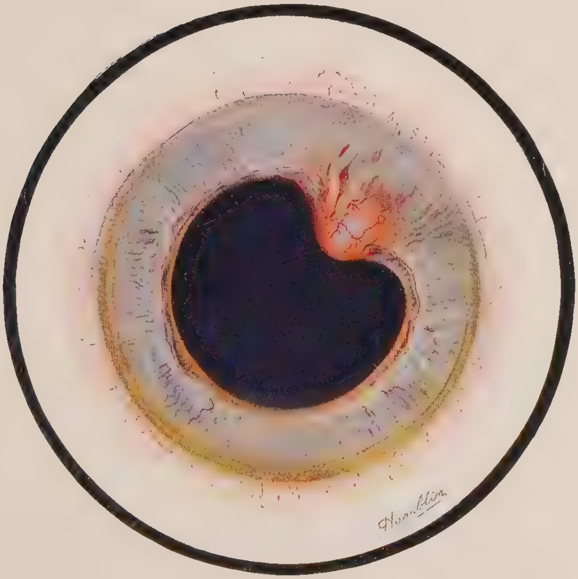
Some forms of long-standing conjunctivitis are complicated by an extension of the inflammation on to the surface of the cornea with leucocytic infiltration and vascularization of its superficial layers, with the result that the visual acuity is reduced considerably.

(2)—Ulceration of Cornea, Keratitis

Causes Ulceration of the cornea may follow an infected corneal abrasion, undue exposure of the cornea in certain febrile diseases, marasmus, lagoph-



A.—Coloboma of the optic disc



B.—Syphilitic iritis, secondary stage

PLATE III

[*To face p.* 422

thalmos, exophthalmos, paralysis of the orbicularis muscle, trophic disturbances affecting the first division of the 5th cranial nerve such as herpes ophthalmicus, after alcohol injection of the Gasserian ganglion for tic douloureux, and sometimes in malnutrition and lowered constitutional conditions.

Sloughing of the superficial layers of the cornea, an interstitial abscess, hypopyon, perforation of the ulcer, iritis and intra-ocular infection, and subsequently a central corneal nebula, adherent leucoma and anterior staphyloma may seriously spoil the vision.

Treatment

In some instances it is possible to prevent ulceration of the cornea by repeated cleansing of the conjunctival sac with saline or mild antiseptic irrigations, instillations of sterile liquid paraffin, a protective shield, or suturing the lids together over the globe. When ulceration has occurred a few drops of pantocain (1 per cent) should be instilled, the sloughing tissue carefully curetted and the edges and floor of the ulcer treated by an application of carbolic acid applied on the end of a matchstick or other suitable applicator. Atropine (1 per cent in oil) is instilled and the eye covered with a pad or bandage. Frequent irrigations of mild antiseptic lotion, hot bathings and atropinization should follow until healing is evident, when dark glasses and applications of dilute mercuric oxide ointment (1 per cent) may be employed. The density of a corneal opacity, unless the iris becomes adherent to the site of the ulcer, may continue to clear for so long as a year.

Hypopyon

An extensive hypopyon is in some cases best evacuated by paracentesis and seizing the coagulated material with forceps and withdrawing it through the corneal wound. It is sometimes advisable to anticipate perforation of the cornea by performing paracentesis, after which the nutrition of the cornea improves. An extensive corneal ulcer, with pus in the substantia propria and on the point of perforating, is in some cases best treated by a Saemisch section, made by passing a thin ground-down Graefe knife into the anterior chamber and cutting out through the floor of the ulcer.

Evisceration is necessary for panophthalmitis. Optical iridectomy and corneal grafting may restore some vision in selected cases in which a dense central leucoma spoils the sight. General treatment consists in raising the patient's resistance. Cod-liver oil and malt, a tonic and small doses of thyroid are sometimes efficacious.

Vaccinia: smallpox

A cow-pox pustule following vaccination, or a smallpox pustule, may involve the cornea by direct infection from contact with an affected area, producing a disciform keratitis. The ravages of this mishap are relatively rather common in India. Treatment consists in irrigations, the application of heat and atropine.

Phlyctenular keratitis

Phlyctenular keratitis affects children living under poor hygienic conditions and is often associated with lymphoid hyperplasia elsewhere in the body, such as enlarged tonsils and adenoids. A depressed state of health and intranasal infection accompany the disease in a number of cases. It appears as one or more patches of leucocytic infiltration which begin in the conjunctiva at the limbus and in the case of fascicular ulcers extend in a snail-like track towards and across the centre of the cornea. A leash of blood-vessels accompanies the affected tract, the advancing edge of which sometimes stains with fluorescein signifying superficial ulceration. Photophobia, lachrymation and blepharospasm are the main symptoms. The disease lasts many weeks or months, is liable to recur and may cause serious impairment of vision from scarring of the centre of the cornea.

Treatment

Treatment should be directed to improving the conditions of living; transference to the country, attention to tonsils and adenoids and nasal sepsis, general ultra-violet light, fresh air, good food, and cod-liver oil and malt are necessary. Local treatment consists in irrigation of the eyes, the application of a freshly prepared ointment containing 1 per cent of yellow mercuric oxide and 0·5 per cent atropine, and the wearing of dark glasses. Carbolization of the advancing edge of a phlycten is indicated except when this is near the centre of the cornea, when it is better to allow the disease to extend clear of the centre and then carbolize the advancing edge as this usually remains the densest part of the resultant scar.

Interstitial keratitis

The term interstitial keratitis has quite wrongly come to mean inflammation of the substantia propria of a congenital specific nature due to the *Treponema pallidum*. The *Bacillus tuberculosis* and the *Bacillus leprae* can also produce inflammation in this structure.

The lesion caused by syphilis affects females more often than males in the proportion of 1·8 or 1·5 to 1. The onset is usually about ten to twelve years of age, although it may occur in much younger children and in adults of thirty or over. One eye is usually affected first and then the other at an average interval of eleven weeks. Unilateral interstitial keratitis may be present in some cases of acquired syphilis in adults. Some of the stigmata of congenital syphilis can usually be discovered.

Symptoms

Photophobia, lachrymation and blepharospasm appear early. The cornea is hazy, resembling ground glass. In some areas the opacities (due to lymphocytic aggregations) are denser than at others. Later, leashes of blood-vessels enter the substantia propria from the periphery and give to the zones of lymphocytic infiltration the characteristic appearance of 'salmon patches'. Iritis and anterior choroiditis are complications in some instances. Residual vascularized corneal opacities may spoil the vision.

Treatment

Irrigations, application of heat, atropine (1 per cent) or a freshly prepared ointment of yellow mercuric oxide (1 per cent) with atropine (0·5 per cent), and dark glasses are indicated. Antisyphilitic measures are without any effect on the course of the disease and they do not prevent its appearance in the other eye.

(3)—Inflammation of the Uveal Tract

Causes

Uveitis is caused by a blood-borne infection of either micro-organisms or their toxins, viruses, or certain proteins elaborated at some small point of focal sepsis, which often eludes detection by clinical methods.

These proteins may possess a specific selectivity for the uveal tract or the latter may have acquired hypersensitivity to them. Pyogenic organisms, the *Treponema pallidum*, tubercle bacillus and lepra bacillus may cause uveitis.

Iritis

Vision may become seriously impaired in iritis by occlusion of the pupil with inflammatory exudates which organize, by ring synechiae, iris bombé, complicated cataract, peripheral synechiae and secondary glaucoma.

Cyclitis

In cyclitis the corneal transparency is affected by deposits of leucocytes and phagocytes on its posterior surface, the vitreous becomes cloudy from collections of inflammatory cells and exudate; exudates and cells become organized in the circumlental space and behind the lens in some cases, and the resulting membrane may pull on the retina at the ora serrata and induce a retinal detachment, and subsequently the eye becomes blind and shrinks.

Choroiditis

Choroiditis damages the adjacent retina, ultimately forming a scarred area at the point of choroido-retinal adhesion. If this occurs at or near the macula visual acuity is seriously impaired. Vitreous exudates are also evident in choroiditis.

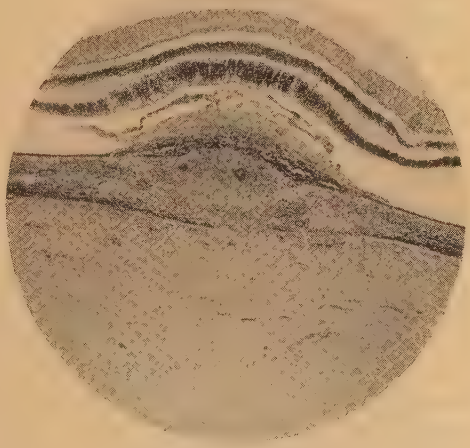


FIG. 71.—Miliary tubercle of the choroid. Note the tubercle in the capillary layer of the choroid. Giant cells and endothelioid cells occupy the centre of the lesion. There is some exudate between the retinal pigment-epithelium and the rods and cones; the latter are undergoing degenerative changes

Treatment of Uveitis

A search for the causal factor should be made and when found dealt with. Syphilis and tuberculosis should be treated by appropriate measures. Iodides and salicylates internally, mercurial inunctions and vapour baths are believed to be beneficial.

Local treatment consists in the application of heat, atropinization to prevent ring synechiae and to put the uveal tract at rest, and dark glasses.

In iritis if the pupil does not dilate fully with atropine a sub-conjunctival injection of mydricain is advisable. Each 5 minim dose of mydricain consists of atropine sulphate 0·008 grain, procaine hydrochloride 0·125 grain, boric acid 0·083 grain, solution of adrenaline hydrochloride (1 in 1000) 1 minim, and sulphurous acid B.P.C 0·007 minim, in sterilized water. In the early stages this may produce the desired effect of breaking down anterior synechiae of recent formation. Dark glasses (Crookes' B2) should be worn. Secondary glaucoma should be treated by appropriate measures. Medical diathermy is of value in some but not all cases. Operative measures such as iridotomy for iris bombé, iridectomy, paracentesis, Herbert's anterior sclerotomy are indicated in suitable cases, but in the majority conservative measures are preferable to surgical operations.

(4)—Retinitis

Inflammation of the retina with accompanying oedema, exudates and haemorrhages may have a profound effect in damaging vision particularly when the macula and central parts are affected. Destruction and atrophy of neurons and nerve fibres, adhesions to the choroid and vitreous and retinal detachment are complications.

Coats's disease

Exudative retinitis (Coats's disease) affects children and young adults, and males more frequently than females. The disease affects the retina in the vicinity of the optic disc. Massive white exudates are present in the retina and in the interretinal space causing retinal detachment. Dilated retinal vessels and haemorrhages in the deeper layers of the retina and between the retina and choroid occur in some cases. Cataract and glaucoma are late complications.

Syphilitic retinitis

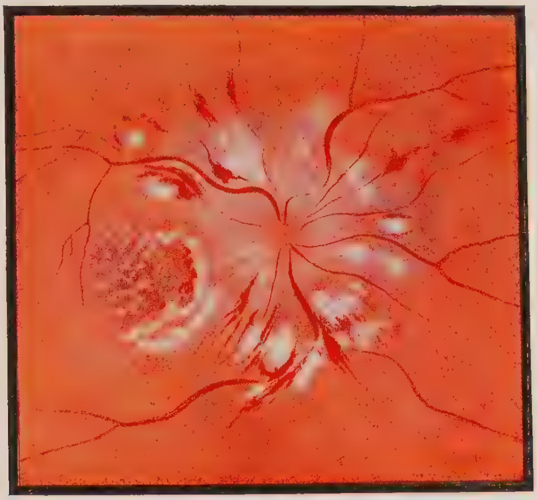
Syphilitic retinitis is of sudden onset. The retina, particularly around the optic disc, is white from oedema and leucocytic infiltration. The veins are engorged and tortuous and the arteries somewhat obscured. Later when inflammation has subsided the retina is pale, white and atrophic, the vessels are smaller than normal and show white sheaths; the edges of the optic disc are irregular and blurred and optic atrophy is evident. Antisyphilitic treatment must be conducted with care. Dark glasses should be worn.

Endogenous pyogenic retinitis

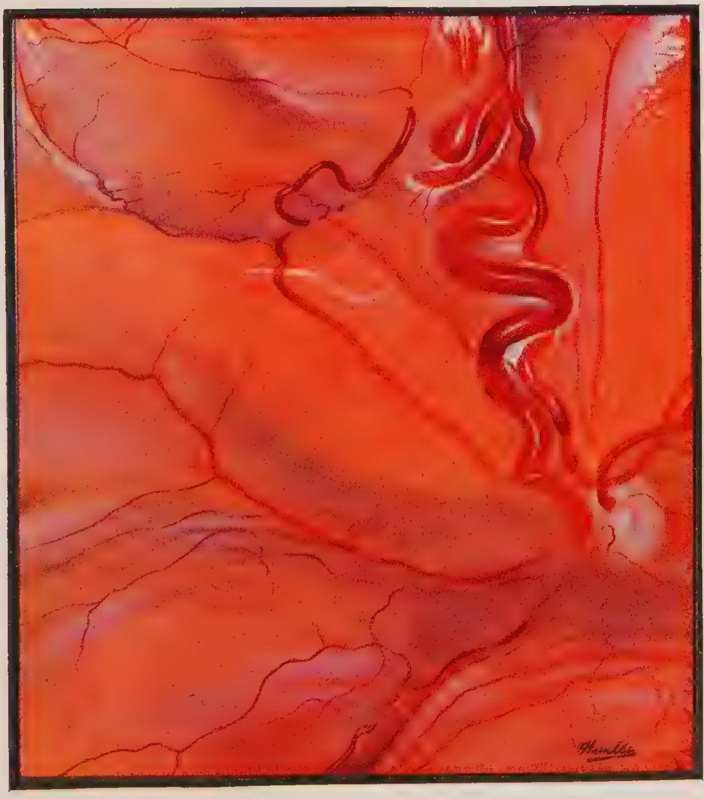
Retinitis may occur in some cases through a blood-borne infection in the form of an infected embolus, for example in puerperal sepsis and pyaemia. Exudates and haemorrhages are present at the affected site. Small round or oval spots are seen near the optic disc accompanied by haemorrhages. The eye should be protected from light and suitable constitutional treatment instituted.

Retinitis circinata

Retinitis circinata is characterized by the formation of a circle or oval of glistening white spots of exudate surrounding the macula and closely following the upper and lower branches of the temporal vessels. The macula is liable to be implicated. The disease affects elderly patients; it may be unilateral and is sometimes bilateral. It is unassociated with any vascular or general constitutional disease. The subjects of the condition are often in particularly sound health. The exudates become absorbed in the course of several years, but macular changes produce permanent damage to vision. Dark glasses and potassium iodide are employed in the treatment.



A.—Albuminuric retinitis, from a case of small white kidney



B.—Angiomatosis retinae, showing dilated and tortuous branches of central retinal vessels and area of gliosis above in the course of these vessels; also exudates and retinal detachment

PLATE IV

[To face p. 426

Retinitis proliferans

Retinitis proliferans is the outcome of organization and vascularization of blood clot in the vitreous. The vessels come from the larger branches of the central retinal vessels in the vicinity of the optic disc. Some special factor is necessary to stimulate this organization. There is a history of syphilis, nephritis, diabetes or a form of toxaemia in some cases. Vision is greatly impaired and may be lost through retinal detachment.

Diabetic retinitis

Exudates and haemorrhages in the vicinity of the macula may seriously spoil the central vision. In diabetes these retinal changes occur in elderly persons and not in the young and are attributed to vascular degeneration. The retinal haemorrhages have a characteristic punctate shape and the exudates appear as bright white spots around the macular region. The changes in albuminuric retinitis may be superimposed on those of diabetes. Arteriosclerosis is often associated with diabetic retinitis. Insulin has no effect on the retinitis.

Albuminuric retinitis

The fundus picture of albuminuric retinitis shows in a number of cases the characteristic star figure at the macula, caused by the presence of exudate under folds of the internal limiting membrane. The fovea remains unchanged. 'Cotton-wool' patches of exudate surround the optic disc. Hyperaemia and retinal haemorrhages, striate and flame-shaped, are evident. (See Plate IV, A.) Papilloedema and haemorrhages on and adjacent to the optic disc may be associated with the retinal changes. In the albuminuric retinitis of pregnancy shallow retinal detachment may be an added complication. On terminating the pregnancy the vision improves but some damage is permanent.

Uraemic amaurosis

Uraemic amaurosis is a condition in the course of nephritis especially associated with uraemia, in which the vision is suddenly and completely lost for several days followed by some recovery. Concomitant renal retinitis is often present but is not the cause of the blindness.

Arteriosclerotic retinitis is described on page 439.

In the above forms of retinitis, treatment on general medical lines should be instituted and dark glasses worn.

(5)—Inflammation of the Optic Nerve

(*a*) *Optic Neuritis*

Symptoms

Papillitis is characterized by hyperaemia, inflammatory exudates, oedema and haemorrhages on the optic disc, the margins of which are blurred. In retrobulbar optic neuritis similar changes in the optic nerve are present behind the globe—the optic disc remaining apparently normal to ophthalmoscopic examination except for slight fullness of the veins in some cases. Deterioration of vision is sudden and rapid, and in retrobulbar optic neuritis movements of the affected eye are painful, particularly on looking up. The pain is increased by pressure upon the globe. The contraction of the pupil of the affected eye is not maintained under bright illumination, the pupil slowly dilating while the light is still kept upon the eye. The visual fields show a scotoma which may be central, paracentral, sectorial or in the form of a ring around the fixation point, relative for colours or absolute, and some peripheral field loss.

Partial optic atrophy varying in degree ensues.

Diagnosis

Investigations should be directed to the detection of sinusitis (particularly of the posterior ethmoids and sphenoids), meningitis, disseminated sclerosis, septic foci, diabetes, and other alleged causes such as rheumatism, chills and infectious diseases.

Diagnosis from papilloedema

It is important to differentiate whenever possible optic neuritis from papilloedema. Clinical features characteristic of optic neuritis are sudden loss of vision with subsequent recovery of a varying degree, whereas the papilloedema due to raised intracranial pressure produces gradual and progressive loss of vision. In optic neuritis the changes at the optic disc margin extend more widely into the adjacent retina and fade off gradually; in papilloedema, however, the optic nerve head is projected forwards to a considerable extent in the advanced stages and the affected zone is more delimited and localized to the immediate vicinity of the optic disc and does not fade off so gradually into the adjacent retina as in cases of optic neuritis. The degree of swelling of the optic disc in papillitis is generally moderate, 2 to 3 diopters, but in papilloedema it may be greater in degree. Retinal changes are present in optic neuritis but a star figure may be present at the macula in some cases of papilloedema in children in the advanced stages of a cerebellar neoplasm, the fan-like striae being complete on the optic disc side of the macula.

Inflammation may become superimposed on papilloedema as a late event, collections of phagocytes attempting to remove the cell debris of tissues destroyed by the effects of pressure. The products of degeneration probably have an irritating effect.

Treatment

Treatment of the cause of the papillitis is necessary. Dark glasses, atropine and abstention from near work are essential. When the cause is obscure, mercury, iodides, salicylates, diaphoresis and tonics may be used.

(*b*) *Disseminated Sclerosis*

The lesions of disseminated sclerosis in the optic nerves, chiasma and tracts give rise to varying grades of optic atrophy. The papillo-macular bundle is especially attacked, resulting in pallor of the temporal side of the optic disc when atrophy has set in. A moderate degree of papilloedema, haemorrhages and exudates may be evident when the lesion is situated close behind the lamina cribrosa. These changes are of short duration.

Loss of vision which may be gradual, but is more often rapid, precedes the optic disc changes, which are of very short duration. The optic disc may show no trace of pathological changes after subsidence of the swelling, and recovery of vision is synchronous with this event.

In the visual fields isolated scotomas, single but often multiple, partial or complete, and more common in the temporal than in the nasal field, are found in a number of cases. Fugitive diplopia from lesions in the abducens and the oculomotor nerves, nystagmus, pupil irregularities when the tracts concerned in the pupillary reflex arc are affected, are other features of the disease affecting the eyes.

(c) *Tabetic Optic Atrophy*

Optic atrophy in tabes may be of slow progress and occur late in the disease. The eyes are usually unequally affected. Paton believed that there may be two types of lesion—a primary neuronic degeneration, and a primary interstitial affecting the optic nerve fibres secondarily. Chronic granulation tissue infiltrates the interstitial neuroglial tissue and the sheaths of the small blood-vessels.

Total blindness may occur in two, three or more years. The optic disc becomes very pale, has a well-defined outline, and atrophic cupping is evident. The pallor of the optic disc may precede visual deterioration. Two types of field are met with, general concentric shrinkage and irregular sectorial defects. Defective dark adaptation and colour vision are early symptoms of tabes.

(6)—Panophthalmitis

Acute infection of all the tissues of the eye, or panophthalmitis, from exogenous or endogenous sources leads to destruction of the intraocular contents. The media become cloudy, the lids and conjunctiva reddened and oedematous, the globe tender and painful. Malaise, headache, drowsiness, vomiting, and a rise of temperature and pulse-rate accompany the disease. Spontaneous perforation of the globe and evacuation of its purulent contents may occur, or it may shrink and become converted into a mass of fibrous granulation-tissue.

Treatment

Applications of heat, atropine, salines and calomel are indicated in the early stages. Some benefit may follow paracentesis and washing out the anterior chamber with hydrogen peroxide solution (10 per cent) in selected cases, but it is usually necessary to eviscerate the contents of the globe after excising the cornea, keeping just inside the limbus. Care must be taken thoroughly to remove the uveal tract. Excision of the globe would open the arachnoid space and introduce the danger of meningitis.

(7)—Other Inflammatory Lesions

Inflammatory lesions in the posterior part of the orbit, the optic canal, the meninges and cavernous sinus—i.e. orbital cellulitis, orbital granuloma, meningitis, and infective cavernous sinus thrombosis—may cause serious damage to the optic nerves and chiasma. Infiltration by inflammatory cells, pressure from exudates and haemorrhages, and ultimately contraction of granulation-tissue and fibrosis, damage the optic nerves and lead to optic atrophy.

Orbital granuloma

Orbital granulomas are sometimes the result of extension of an inflammatory process from the posterior ethmoidal air-cells, or may form around a foreign body impacted in the orbit. Gumma and tuberculoma are also masses of chronic inflammatory tissue which may damage the optic nerve in its orbital course. Very rarely does recovery take place after cavernous sinus thrombosis. The clinical features of these lesions include congestion of the conjunctival and retinal vessels, proptosis, damage to the nerve supply of the intrinsic and extrinsic ocular muscles, papilloedema and panophthalmitis.

Cavernous sinus thrombosis

5.–TUMOURS

153.] Visual loss as a result of a tumour depends on its site and behaviour. It is evident that even a small tumour situated in the retina or choroid at the macula will spoil visual acuity considerably. In some instances secondary changes may have a more damaging effect than the tumour itself. Examples of this are angiomatosis retinae causing retinal detachment, haemorrhages and vascularization of the vitreous; neurofibromatosis of the ciliary nerves in the choroid giving rise to glaucoma, and cataract induced by pressure from a neoplasm of the ciliary body.

(1)—Malignant Melanoma

A malignant melanoma may arise in a group of naevus cells situated at the corneo-scleral junction, which has been present for many years. Clinical evidence of malignancy is increased size and pigmentation of the tumour and the presence of widely dilated and thin-walled blood-vessels in the adjacent conjunctiva. Carcinomatous and sarcomatous histological features are intermingled in some cases. Invasion of and extension across the cornea leads to loss of sight.

Treatment

Treatment in the early stages should consist in forming a barrage of diathermy points around the neoplasm so as to seal off lymphatic vessels draining the affected area, followed by careful and wide excision of the tumour and a prophylactic application of 10 mg. of unscreened radium in a suitable applicator for sixty minutes, four to six weeks after operation. When the tumour has spread extensively over the cornea complete or partial exenteration of the orbit is indicated.

(2)—Sarcoma of the Uveal Tract

Incidence

Pigmented and non-pigmented sarcomas of the uveal tract are rare and occur in about 0·06 per cent of patients attending a large eye hospital. They are more prevalent in the fifth and sixth decades of life and affect the sexes about equally. In 85 per cent of cases the neoplasm is present in the choroid, 9 per cent in the ciliary body and 6 per cent in the iris.

Diagnosis

With the ophthalmoscope a dark greyish-brown mass is seen, over the summit of which, in the case of a tumour arising from the choroid, the retina is stretched. On either side the retina becomes detached and an early feature of this is the presence of lines of tension in the retina overlying the periphery of the tumour. Pigmented spots and a few white exudates are sometimes present in the retina over the tumour. A vitreous haemorrhage is evident in some cases. On transillumination the affected site yields a dull pupillary reflex. Secondary glaucoma and extra-ocular extension along the optic nerve, emissary vessels and ciliary nerves are later complications.

Sarcoma of the ciliary body is sometimes seen on focal illumination. It may infiltrate the iris root and cause cataract by local pressure on the lens. Sarcoma of the iris may take the form of a single nodule of neoplastic cells, or it may diffusely infiltrate the iris stroma and ciliary body, the so-called 'ring sarcoma'.

Treatment

A well localized nodular sarcoma of the iris which has not invaded the filtration angle may be treated by a wide iridectomy and be kept under observation. Sarcoma elsewhere in the uveal tract necessitates excision of the eye and subsequent treatment of the orbit with deep X-rays or radiotherapy if extra-ocular extension has been discovered on histological examination of the globe. The insertion of a radon seed into the tumour, or the suturing of radon seeds to the sclera over its site, is worth a trial when the affected eye is the only one remaining and if some healthy retina is still present.

(3)—Metastasis in Choroid

A metastasis of carcinoma cells in the choroid is rare. The malignant embolus is carried into a posterior ciliary artery and lodged in the choroid, producing a flat pancake-like thickening generally in the post-equatorial region and presenting ophthalmoscopically a yellowish-grey mass with indefinite edges. A shallow retinal detachment overlies the tumour. Pigment deposit and a few white spots are present in the detached retina. Loss of sight and perforation of the sclera are sequelae. The primary growth is situated in the breast, lungs, and more rarely the stomach, ovary, prostate or thyroid. Death occurs in four to seven months after ophthalmological detection of the metastasis. Excision of the eye is only done if pain is severe.

Site of primary growth

(4)—Glioma Retinae

Glioma retinae is a congenital malignant tumour affecting the retina in infants and young children. An hereditary and familial incidence is found in a number of cases. Both eyes are affected in 23 per cent. A grey pupillary reflex is first noted by the child's parents and by this time the disease is usually well advanced in one eye. The tumour has a greyish-white flocculent appearance like cream cheese and shows capillary loops in its substance. Fragments of the tumour become broken off, circulate in the intra-ocular fluids, and become implanted in other parts of the eye such as the ciliary processes, the anterior crypts of the iris, the choroid and filtration angle. Secondary glaucoma, fungation through the corneo-scleral junction, infiltration of the lamina cribrosa and optic nerve, extra-ocular extension and intracranial infiltration are among the late sequelae which precede death.

Treatment Excision of the affected eye is indicated. When the disease has affected the other eye in which there is some healthy retina that may be useful, radiotherapy by suturing 2 millicurie radon seeds over the affected area is justifiable.

(5)—Angiomatosis Retinae (von Hippel-Lindau's Disease)

Angiomatosis retinae is rare. The fundus lesions are often bilateral, one eye being affected before the other. Bunches of dilated capillaries and glial tissue may be seen on the edge of the optic disc in the equatorial region or far forward near the ora serrata.

Running to and from these sites are greatly dilated arteries and veins. Bunches of dilated capillaries may appear elsewhere in the fundus and retinal and vitreous haemorrhages may occur (see Plate IV, B). Retinal detachment and vascularization of the vitreous are late events. The age-incidence is twenty-five to thirty-five years and the disease is often associated with cerebellar cysts, similar lesions in the medulla and spinal cord and tumours in the kidney, suprarenals and other viscera.

Treatment In the early stages the growth of an affected area in the retina may be arrested by radiotherapy, radon seeds being sewn to the sclera over the site of the lesion. Obliterative endarteritis is thereby produced.

(6)—Tuberous Sclerosis

Tuberous sclerosis is a rare disease in which characteristic cerebral lesions, mental deficiency and adenoma sebaceum form the clinical picture. Ocular lesions in this disease may affect the optic disc or any part of the retina, and are represented by round or oval greyish-white areas two or three times the size of the optic disc and composed of neurocytes and neurofibrils.

(7)—Neurofibromatosis

Neurofibromatosis may affect the ciliary nerves producing a plexiform neuroma in the choroid. Such a condition may lead to buphthalmos (infantile glaucoma) in young persons and to glaucoma in adults. The optic nerve may also be the site of the disease. Proptosis and displacement of the globe downwards and forwards, enlargement of the optic foramen and destruction of the bony apex of the orbit with transmission of pulsation from the cerebrospinal fluid circulation are physical signs.

Treatment Treatment is of little avail. Trephining for glaucoma may give only temporary relief.

(8)—Tumours of the Optic Nerve and its Sheaths

Damage to the optic nerve may occur as the result of pressure effects from tumours arising in its sheath, such as fibroma and fibro-sarcoma of the dura, meningioma (endothelioma) of the arachnoid, and tumours of the optic nerve itself such as endothelioma, glioma and neurofibromatosis. Mestastatic deposits of carcinoma in the optic nerve occasionally occur.

Tumours of the optic nerve and its sheath are slow-growing. Increasing hypermetropia due to forward displacement of the back of the globe, then proptosis and loss of vision are suggestive physical signs. Papilloedema resembling optic neuritis and retinal detachment are present in some cases.

Treatment

Rarely it is possible to remove a tumour from the optic nerve sheaths. Deep X-ray therapy or radium are worth a trial, but failure to arrest the growth of the tumour with these agents will necessitate exenteration of the orbit.

(9)—Tumours of the Orbit and its Walls

Tumours arising in the orbit and its walls may seriously damage vision by compressing and infiltrating the optic nerve. Osteoma and sarcoma of the bony walls, carcinoma of the lachrymal gland, and carcinomatous metastases may occur; teratomas containing teeth have occurred.

Treatment

Treatment by excision of the neoplasm, exenteration, deep X-rays, and radium should be considered in order to decide which is most appropriate for the individual case.

(10)—Cysts

Defective vision may be caused by a congenital dermoid cyst covering a large part of the cornea. An implantation cyst may follow a penetrating wound of the cornea or anterior chamber, epithelial cells being carried into the cornea and anterior chamber and multiplying. Occasionally a traumatic cyst contains a foreign body such as an eyelash. Corneal epithelial cells may be implanted in an anterior crypt of the iris and, receiving nourishment from the stroma, form a cyst which increases in size and may occupy a large part of the anterior chamber. After an operation in which a corneal section is made, epithelial cells may line the anterior chamber. In suitable cases surgical removal of the cyst should be attempted.

Parasitic cysts, such as hydatid and cysticercus, may appear in the vitreous chamber. In the latter the parasite may be seen ophthalmoscopically as a pearly translucent mass with peristaltic movements. Surgical removal is very difficult. (See HYDATID DISEASE and CYSTICERCOSIS.)

6.–DEGENERATIONS AND OPTIC ATROPHY

(1)—Degenerations of the Cornea

(*Xerophthalmia,* see page 451, on Diseases due to Nutritional Deficiences.)

Calcareous band

154.] A transverse calcareous band occurs in cases in which there has been corneal oedema of long standing, as in iridocyclitis, blind glaucomatous eyes and in senile subjects. The calcareous band occupies the palpebral fissure in the most exposed part of the cornea. There is a clear margin of cornea separating the lateral extremities of the band from the limbus. The lower margin is straight and the upper concave upwards. The calcareous deposits are densest at the extremities.

Treatment

The eye should be excised if it is blind, painful and unsightly. Sometimes a horizontally oval area of calcareous degeneration occurs in eyes otherwise healthy. As the calcareous deposits are quite superficial removal by scraping off the opacity should be attempted.

Corneal opacities

Nodular and reticular opacities in the cornea are rare congenital conditions in which there is a familial and hereditary incidence. The disease begins in young males about the age of ten or twelve. In the nodular type small round, irregular, grey, discrete opacities are present in the superficial layers of the centre of the cornea, the periphery remaining clear and unaffected. The disease is bilateral, the opacities increase and vision becomes progressively worse. There is little or no inflammatory reaction.

In the reticular type the central superficial layers of the retina are affected by a network of fine grey lines, presenting ridge-like elevations of the corneal surface. Thickened corneal nerves and nodular swellings on the nerve-endings, and folds or ruptures of Bowman's membrane are seen in some cases. Vision is gradually obscured. Treatment is of little avail.

Mooren's ulcer

Mooren's ulcer is a condition which is characterized by an extensive loss of corneal tissue, sometimes a half to two-thirds of the thickness of the cornea over most of its surface. It begins by one or more grey infiltrates which break down and form small ulcers which coalesce. These changes affect elderly persons. The disease is bilateral in many cases and unaccompanied by more than slight inflammatory signs. Blood-vessels pass from the limbus across the floor of the ulcer, the edges of which are steep and undermined like miniature cliffs with an overhanging edge composed of epithelium. Perforation never occurs, iritis is sometimes a complication and very rarely there is a small hypopyon. The cause is unknown.

Treatment

Gentle curetting and covering the entire cornea with a conjunctival flap is said to give good results in some cases. Zinc ionization and radium are recommended by some authorities but in many cases treatment is of little avail.

(2)—Degenerations of the Macula

Tay-Sachs' disease

Amaurotic family idiocy (*Tay-Sachs' disease*) is a disease of the nervous system in which the primary changes occur in the nerve cells with disappearance of the Nissl granules and the deposit of lipoid in the cytoplasm of some of the cells and in the cell processes. The disease affects Jews but a few cases among Gentiles have been reported. There is a familial incidence.

Symptoms begin during the third to sixth month of life with defective vision and weakness of the neck and back. At the macula there is a cherry-red spot darker in colour than that seen in central retinal artery embolism. The retina adjacent to the macula has an opaque greyish-white colour due to the presence of lipoid granules in the ganglion cells of this area of the retina. At first the optic disc is unaffected but later it becomes pale and white and the retinal arteries constricted. Mental deficiency, muscular weakness and marasmus are later complications prior to death.

Batten-Mayou disease

Juvenile cerebro-macular degeneration (*Batten-Mayou disease*) occurs at about six to eight years of age and is not confined to Jews. There is a marked familial tendency. Epilepsy, mental deficiency and imbecility are associated with the macular changes and death takes place approximately six years from the onset of the disease. The macula shows brownish pigmentary disturbances.

Adolescent macular degeneration

Adolescent macular degeneration is characterized by pigmentary changes with loss of central vision occurring at the macula about puberty. There is a familial tendency but no mental deterioration and a fatal result does not ensue.

Senile macular degeneration

Senile macular degeneration affects persons in the fifth and sixth decades of life. There is sometimes a history of this affection in other members of the family. Yellowish-white, irregular-shaped dots and pigment deposits are present at the macula. Central vision is much impaired and a central scotoma is present, the patient being unable to read but capable of seeing his way about.

There is no effective treatment for these conditions (see Vol. III, CEREBRO-RETINAL SYNDROMES).

(3)—Degenerations of the Retina

Retinitis pigmentosa

Retinitis pigmentosa (pigmentary degeneration of the retina) is not, as the name suggests, an inflammatory disease but a degeneration. Hereditary and sex linkage factors are concerned in its aetiology and consanguinity augments its tendency to occur. The vascular theory supports the idea that the choriocapillaris is damaged by disease and thus affects the nutrition of the outer layers of the retina. Leber, Treacher Collins, Verhoeff and others believed that the disease is a progressive degeneration of the retinal neuro-epithelium, the rods being first affected. The disease begins in childhood, and progresses towards blindness as age advances but with greatly varying rapidity. Degenerative changes are bilateral and begin in a zone near the equator and gradually spread anteriorly and posteriorly.

Symptoms

Night-blindness is the earliest symptom. Some years later pigment spots in the characteristic form of bone corpuscles appear in the fundus near the equator. Partial or complete annular scotoma is found corresponding with the degenerated zone of the retina. Progressive loss of visual field occurs until a narrow zone around the fixation point remains. Loss of this central vision may not happen until fifty or sixty years of age but it may occur earlier through a posterior polar cataract which complicates this disease.

The choroidal vessels become visible on fundus examination owing to the migration of retinal pigment and retinal atrophy. Pigment is found in the sheaths of the retinal veins. Later the retinal arteries become attenuated, the retina atrophic and the optic disc pale and waxy in appearance.

Retinitis pigmentosa sine pigmento is a variety of the disease with the same symptoms but no ophthalmoscopic evidence of pigment deposits in the retina. It is probably an early stage of the disease which is followed later by the typical pigment deposits. It is progressive and leads to optic atrophy.

Several generations may be affected by retinitis pigmentosa. Mental deficiency, idiocy, epilepsy, deafness, dumbness, spinal paralysis, harelip, supernumerary digits and a characteristic lisp in the speech are associated defects.

Treatment

Treatment is unsatisfactory. A good diet containing added vitamin A, and strychnine by the mouth or by hypodermic injection are recommended. The constant current has been advocated. Temporary improvement has followed a trephine operation at the corneo-scleral junction (Mayou). Extraction of the lens may cause a slight improvement of vision if cataract is present but should not be performed until a late stage is reached. Cervical sympathectomy has been tried but its effect and results are of doubtful value. Some authorities make extravagant claims for the arrest of the disease by this procedure but others do not confirm this optimistic view; the disease is in fact not controlled by any form of treatment.

Retinitis punctata albescens

Retinitis punctata albescens is probably an atypical variety of retinitis pigmentosa and may occur in a family affected by it. It is, however, non-progressive. Numbers of small white dots are fairly uniformly distributed over the whole fundus. Night-blindness and contraction of the peripheral visual fields occur. Cataract, pallor of the optic disc and attenuated retinal vessels are not noted in this disease.

Laurence-Moon-Biedl syndrome

The *Laurence-Moon-Biedl syndrome* consists of retinitis pigmentosa, adiposity and hypogenitalism (Fröhlich's syndrome), mental retardation, polydactyly and in some cases macular changes resembling those seen in cerebro-macular degeneration. The complete picture is not always present but affected members of a family in which this syndrome occurs may each show several of its features, the sum total of their clinical signs constituting the complete syndrome (see Vol. III, CEREBRO-RETINAL SYNDROMES).

Doyne's honeycomb familial choroiditis

Doyne's honeycomb familial choroiditis is characterized by the formation of light-coloured patches in the neighbourhood of the optic disc and macula with or without pigmentary disturbances. The disease is bilateral and progressive. Patches of hyaline degeneration occur on Bruch's membrane, which becomes thickened. These patches become larger and coalesce and in the macular region cause serious impairment of vision. The disease occurs in early adult life, is hereditary and affects several members of a family. It is probably due to degenerative changes which occur primarily in the retinal pigment epithelium.

Leber's optic atrophy

Leber's optic atrophy affects males and rarely females. Its manifestations occur between eighteen and twenty-three years of age. It is familial and transmitted in a sex-linked manner through the females. Its occurrence in five generations has been reported. The disease may skip a generation. Both eyes are affected. The onset is rapid in some cases and gradual in others. Vision fails and there is an absolute central scotoma for white and colours. The edges of the optic disc are slightly blurred owing to oedema and later the temporal half becomes pale. There is a tendency for vision to recover after the initial failure, but this is rarely complete and, although those afflicted never become totally blind, serious visual impairment is the rule.

(4)—Optic Atrophy

Many of the causes of optic atrophy are dealt with in other sections of this article. The following is a summary of some of the more important lesions which may cause optic atrophy. The investigations necessary to elucidate the aetiological factors responsible for this disease will occur to the reader on reviewing the sites and nature of the lesions affecting the optic nerve fibres.

Local Lesions

Summary

(i) *Retina.*—Retinitis. Retinal detachment. Pigmentary degeneration of the retina (retinitis pigmentosa). The macular degenerations affecting the papillo-macular bundle. Glaucoma. High myopia. Embolism or thrombosis of the central retinal artery. Glioma retinae. Angiomatosis retinae.

(ii) *Optic nerve head.*—Avulsion. Papilloedema. Papillitis. Tuberculoma. Gumma. Angiogliomatosis. Tuberous sclerosis.

(iii) *Retrobulbar portion of optic nerve.*—Tears. Subdural haemorrhage Retrobulbar neuritis. Cellulitis of the orbit. Chronic granulomas, chronic pyogenic, tuberculous and syphilitic infections. Tumours of the optic nerve and its sheaths, of the orbit and nose.

(iv) *Optic foramen.*—Hyperostosis. Fractures through the optic foramen. Callus formation. Arteriosclerosis of the ophthalmic artery. Meningitis. Sarcoma of the sphenoid. Oxycephaly. Sphenoidal sinusitis.

(v) *Intracranial part of optic nerve.*—Arteriosclerosis or aneurysm of the internal carotid artery compressing the optic nerve. Trauma. Meningitis. Intracranial tumours.

(vi) *Chiasma.*—Trauma. Meningitis. Pituitary tumours. Glioma. Hydrocephalus. Aneurysm of the internal carotid artery, ophthalmic artery and circle of Willis. Intracranial tumours.

Diffuse Causes of Optic Atrophy affecting other Parts of the Central Nervous System

Tabes. Disseminated sclerosis. Poisons such as tobacco, alcohol, lead, arsenic (see p. 452).

7.–VASCULAR AND BLOOD DISEASES

(1)—Embolism and Thrombosis

(*a*) *Obstruction of Central Retinal Artery*

155.] An embolus detached from a vegetation on the mitral valve may lodge in the central retinal artery or one of its branches. The left eye is affected more often than the right.

Thrombosis may occur from arteriosclerotic changes and endarteritis. Spasm of the artery wall is probably responsible for those cases in which a remarkable recovery takes place. Premonitory symptoms such as transient attacks of blurred vision have occurred in some of these cases. The vision is lost suddenly and this emergency requires prompt attention if sight is to be saved. The optic disc and macula are surrounded by a pale milky white area of retina, which renders the outline of the optic disc indistinct. A cherry-red spot is seen at the fovea where the choroidal circulation shows through. The arteries are very attenuated and represented as thin white lines. The veins are slightly full and in some cases the column of blood is broken up into red beads separated by clear intervals. The beads move in a jerky fashion sometimes in the normal direction of the blood-flow, sometimes the opposite. In several weeks the coagulation necrosis clears up and the retina regains its transparency but is atrophic.

In some cases the feeble anastomosis around the optic disc establishes circulation in the cilio-retinal arteries and central vision is spared to some extent, or a macular branch is occasionally given off from the central retinal artery proximal to the obstruction. An arterial block may occur in the macular branch of the cilio-retinal arteries.

Treatment Immediate paracentesis of the anterior chamber and massage of the globe to propel the clot into a branch of the central retinal artery is the treatment indicated.

(*b*) *Thrombosis of Central Retinal Vein*

The obstruction in the central retinal vein is often first noticed on waking in the morning; the site of the thrombosis is usually immediately behind the lamina cribrosa. Facial erysipelas and orbital cellulitis are local causes. The veins are very engorged with blood and tortuous. Haemorrhages and exudates in the retina, on the optic disc and in the vitreous are evident.

Thrombosis may occur at arterio-venous crossings in cases of arteriosclerosis and at the bifurcation of a vein. Late events are atrophic changes in the retina with fine pigmentary disturbances especially at the macula; secondary glaucoma develops in 15 per cent of cases in which the central vein is blocked.

The patients are elderly and the subjects of cardiac or vascular disease often induced by nephritis.

Treatment Treatment is of no avail. Drops of pilocarpine nitrate (2 per cent) may forestall the onset of secondary glaucoma. If the eye becomes blind and painful it should be excised.

(c) *Cavernous Sinus Thrombosis*

This generally fatal disease rarely causes loss of vision except when retinal haemorrhages are present and thrombosis extends to the central retinal vein. There are three causes of cavernous sinus thrombosis: infective, from an infected site in the course of any of the venous tributaries which ultimately drain into the cavernous sinus; primary or marasmic; traumatic.

Causes

The changes in the eyes are concerned with the obstruction to the venous circulation and the involvement of nerves. Proptosis straight forwards, chemosis of the conjunctiva and oedema of the lids, oedema of the retina and swelling of the disc and tortuous veins may be found. Frequently the fundi do not show any abnormality. Supra-orbital neuralgia, ptosis, ophthalmoplegia interna and externa, and corneal anaesthesia may occur from involvement of the nerves. This is more liable to happen in infected cases and in association with orbital cellulitis. One of the early signs is paralysis of the external rectus muscle on the affected side. Points of diagnostic importance are transference of the signs to the other eye and orbit and oedema over the mastoid region at the site of the mastoid emissary vein. Typical papilloedema is commonest in otitic cases and represents meningitis and cerebral abscess; it is bilateral but more pronounced on the side of the aural lesion. Simultaneous thrombosis of both cavernous sinuses with proptosis and papillitis may occur as a complication of sphenoidal sinusitis.

Changes in the eyes

A raised temperature, rigors, vomiting and cerebral symptoms may also be present.

The infective cases almost invariably prove fatal, but a few patients have recovered from simple thrombosis without infection.

Prognosis

General treatment is directed towards dealing with the infective focus, administering intravenous glucose with injections of insulin, and immuno-transfusion if practicable.

Treatment

Attempts to remove the clot surgically have been made but are fraught with hazards. The temporal approach as for exposure of the trigeminal ganglion has been tried but is more difficult than the orbital approach which aims at draining the cavernous sinus through the sphenoidal fissure after exenteration of the orbit. When the diagnosis is free from doubt this procedure is justifiable so long as the thrombosis is confined to one side and there is not any other grave complication such as meningitis and cerebral abscess.

Local treatment is directed towards protection of the cornea.

(2)—Arteriosclerosis

Degenerative changes in the retina may occur as a result of arteriosclerotic changes in the retinal vessels and in the choroidal circulation. Characteristic changes seen on ophthalmoscopic examination are

Ophthalmoscopic examination

compression and obscuration of the veins at the arteriovenous crossings; alterations in the light reflex and irregularities of calibre in the retinal arteries, 'copper wire' and 'silver wire' arteries; haemorrhages and round discrete yellowish spots of hyaline exudate at the macula and in the perimacular region. Vascular tortuosity, attenuation and beading of the veins are other features. Miliary aneurysms are rare. These vascular changes are often associated with similar alterations in the cerebral arteries, particularly the anterior and middle cerebral.

Choroidal sclerosis

Extensive arteriosclerotic changes in the choroid impair the nutrition of the outer layers of the retina which become atrophic and thin, showing on fundus examination irregular-shaped deposits of pigment which have migrated from the retinal pigment epithelium through the external limiting membrane, and attenuation of the retinal vessels. The changes in the choroidal vessels are readily seen on ophthalmoscopic examination. Some of the vessels are completely occluded and appear as tortuous white cords, others have a thin central red streak where blood is circulating. There are yellowish coloured areas of hyaline degeneration and irregular patches of pigmentation. The optic disc shows atrophic changes. Vision is much impaired.

(3)—Eales's Disease (Recurrent Vitreous Haemorrhage)

Recurrent vitreous haemorrhages without any clinical evidence of gross pathological changes in the ocular structures to account for them, affect males between seventeen and twenty-five years of age and, very rarely, women. Both eyes are usually affected during the course of the disease. The aetiology is at present unknown. A general medical examination and pathological investigations fail to reveal any feature which might account for the haemorrhages. The affected individuals are sometimes lacking in spirits and energy and some are subject to intestinal stasis and epistaxis. A slow pulse, low blood-pressure and functional albuminuria are sometimes present.

The onset is sudden and begins in one eye. Loss of vision, except when the haemorrhage is at the macula, is proportionate to the degree of vitreous opacity caused by the haemorrhage. A peculiar feature of this disease is that the vitreous haemorrhages clear rapidly in the course of two or three weeks. Recurrences are common for some years. In most cases the haemorrhages come from the retinal vessels at the periphery of the fundus. Complications are retinitis proliferans, secondary glaucoma and iritis.

Treatment

As the haemorrhages recur whether the patient lies in bed or is up and about, absolute rest is not essential and indeed tends to augment the mental depression characteristic of these patients. Mild exercise, tonic treatment and the correction of intestinal stasis when such exists are necessary. Attempts to check the recurrence of haemorrhage by the administration of calcium and parathyroid, horse serum and anti-diphtheritic serum have not met with appreciable success. Potassium iodide and thyroid have been found beneficial by some authorities and injections of old tuberculin is recommended by some. Atropine, subconjunctival injections of ethylmorphine hydrochloride (dionin), saline (1 to 10 per cent) not more than 10 minims daily, and medical diathermy applied locally have been tried.

(4)—Anaemia

Visual disturbances and impairment of vision may occur in cases of anaemia, from defective nutrition of the retinal elements and from damage by haemorrhages and exudates.

Pernicious anaemia

In some cases of pernicious anaemia retinal haemorrhages, small, flame-shaped or roughly circular, situated in the nerve-fibre layer in the posterior part of the eye are seen. Engorgement of the retinal vessels, pallor of the fundus and optic disc due to a faint opalescent haze are also features of the general anaemia. Vision is seldom seriously impaired except by a haemorrhage at the macula.

Chlorosis

Papilloedema is described as one of several pathological changes in the eye associated with chlorosis, now an almost extinct disease, but great care is needed to exclude other aetiological factors. The vision is restored by iron treatment.

Erythraemia

In erythraemia (Vaquez's disease) very seriously impaired vision ending in blindness may occur, with marked ophthalmoscopic changes amounting to extreme engorgement of retinal veins with haemorrhages (the arteries being of normal size), and papilloedema, or without any apparent fundus lesions except slight fullness of the retinal vessels and hyperaemia of the optic disc.

Purpura haemorrhagica

In purpura haemorrhagica retinal and sub-retinal haemorrhages are not uncommon. All the layers of the retina may be affected in the posterior part of the eye.

Cyanosis retinae

In some cases of congenital heart disease the retinal vessels are dark in colour (cyanosis retinae), the arteries being the colour of normal veins and the veins much darker. Retinal haemorrhages in the posterior part of the globe are not infrequent, but never so profuse as in erythraemia.

Leukaemia

Ophthalmoscopic changes are frequently associated with leukaemia. The earliest change is engorgement of the retinal veins and, in about 44 per cent of cases, of the retinal arteries as well. Approximation in colour of the retinal veins and arteries is the next stage, the vessels appearing as though they contained diluted blood. Retinal haemorrhages may be profuse or scanty. They may be present throughout all the layers of the retina and burst into the interretinal space. Another stage of this disease is a pale or greenish fundus reflex due to a general leucocytic infiltration of the retina and choroid, the veins showing as broad white lines from perivascular infiltration. Blurring of the optic disc edges from oedema may be present. Narrowing of the visual fields and nyctalopia may also occur.

(5)—Chloroma

Chloroma

Gallemaerts reports a case in which dissemination of a chloroma took place in the retina and choroid of one eye.

(6)—Angioneurotic Oedema

Horniker described several cases of angioneurotic diathesis which showed changes at the macula and in the adjacent retina. Most of these patients were between thirty and forty years of age, the symptoms were sudden impairment of vision like a scintillating scotoma, a mist variable in colour in front of the centre of the object fixed upon with sensations of movements in the mist and an increase in the size of Maxwell's spot. Oedema, haemorrhages and blurring of the central reflex are noted at the macula. The prognosis is generally good but there is a tendency to relapse.

(7)—Haemorrhage

Blindness sometimes follows a sudden severe haemorrhage from the gastro-intestinal tract and uterus, rarely is it a sequel to a prolonged drain of blood. Very rarely does loss of sight follow traumatic haemorrhage. There is often an interval of days between the affection of one eye and the other. Loss of vision is probably due to anoxaemia of the retina and there is little tendency for the sight to be recovered. Ophthalmoscopic signs immediately after the haemorrhage are pallor of the fundus, blurring of the edges of the optic disc, reduction in size of the vessels, and near the optic disc the retinal veins have the same colour as normal arteries. Later on pallor and a sharp outline of the optic disc are evident.

Prolonged and severe compression of the chest (traumatic asphyxia) may cause bluish-grey patches of oedema in the nerve-fibre layers, and in some cases a large area of exudate at the centre of each fundus and a few retinal haemorrhages. The exudate clears in about two months, but the central vision is impaired.

8.–INTRACRANIAL LESIONS

156.] Intracranial lesions may affect the optic nerves, chiasma, tracts and radiations. Conduction of impulses along the optic nerve fibres and optic radiations to the visual cortex may be interrupted or impaired by traumatic and inflammatory lesions, by pressure from haemorrhages, aneurysm, exudates, fibrous tissue, abscess, granuloma, neoplasm or a cyst.

Trauma

Trauma to the occipital region may result in blindness in those parts of the visual field corresponding with the damaged area of occipital cortex. Mention has already been made of fractures of the anterior fossa of the skull in which the optic foramen may be implicated, and on account of the intimate attachment of the dura to the bone and the optic nerve the latter is often torn, optic atrophy being evident on ophthalmoscopic examination about three weeks after the accident. Callus formation and blood inside the dural sheath may compress the optic nerve.

Pressure

Vascular diseases in the nature of arteriosclerosis, particularly of the internal carotid and ophthalmic arteries, may cause damage from pressure effects on the optic nerve and chiasma. Thrombosis of the posterior cerebral artery will cause homonymous hemianopia; a cerebral haemorrhage may damage some of the optic radiations.

Aneurysms arising from the internal carotid artery near its termination, the ophthalmic artery, and the circle of Willis may compress and damage tracts of nerve fibres in the optic nerve, the chiasma and optic tract. Aneurysms of the circle of Willis are due to congenital defects in the tunica media and are seldom larger than a pea. Rupture of an aneurysm may be accompanied by sudden pain in the fronto-temporal region of the affected side followed in a few hours by loss of consciousness and subdural haemorrhage. Later large round haemorrhages may appear on the edge of the optic disc, beneath the hyaloid membrane and in the vitreous. Recovery, if it occurs, is attended by symptoms of cerebral irritation and often paralysis of one or several of the cranial nerves which pass to the orbit. Visual field defects are present and there is blood in the cerebro-spinal fluid. (See also BRAIN: VASCULAR DISORDERS, p. 646.)

Meningitis

A moderate degree of papillitis is common in about 25 per cent of cases of tuberculous meningitis and is generally bilateral. Miliary tubercles appear in the choroid two or three days before death. Papillitis, never papilloedema, is frequent in epidemic cerebrospinal fever. Sporadic acute basal meningitis in children due to the meningococcus may cause complete loss of sight with normal fundi and normal pupil reactions, due to the action of toxins on the higher visual centres. Blindness may persist for many weeks after the subsidence of other symptoms but sight eventually be restored. Purulent meningitis from typhoid, pneumonia, influenza, scarlet fever, measles, otitis media and septicaemia may cause papillitis.

Encephalitis

Papillitis is rare in epidemic encephalitis.

Cerebral syphilis

The optic nerves, chiasma and tracts are involved in the basal gummatous meningitis which is the chief form of cerebral syphilis. Papillitis, papilloedema and post-neuritic atrophy are usually bilateral. Homonymous hemianopia from affection of one tract, temporal hemianopia and central scotoma are evidence of involvement of the paths of the optic nerve fibres. Inconstancy and variability of the symptoms, temporary and recurrent visual and oculomotor disturbances are characteristic of basal gummatous meningitis.

Intracranial abscess

Papilloedema on the affected side is a clinical sign of considerable importance for the localization of an intracranial abscess. It persists longer after the operation for cerebral abscess than after the removal of a cerebral tumour or decompression of the skull, and it may even begin after the operation. Retinal haemorrhages and ocular palsies may accompany the papilloedema.

Homonymous hemianopia indicates a lesion of the occipital lobe. Partial third nerve paralysis with contralateral hemiplegia indicates an abscess of the temporal lobe.

Hydrocephalus

In congenital and early acquired hydrocephalus, papilloedema is rare. The eyeballs deviate downwards, and upward movements are much restricted. Optic atrophy is a later complication.

In acquired hydrocephalus of later life bitemporal hemianopia is produced by pressure on the chiasma and tracts by the bulging floor of the third ventricle. There may also be evidence of meningitis. Remissions and intermissions of long duration occur with visual defects due to post-neuritic atrophy.

Intracranial tumours

Papilloedema is the commonest ocular manifestation of intracranial tumours. The degree of swelling of the optic disc varies with the site of the tumour; in precentral, temporo-sphenoidal, optic thalamus, pontine, mid-brain, cerebellar and extra-cerebellar tumours it is of severe degree, whereas in post-central, subcortical, and ventricular tumours it is moderate.

Loss of vision without papilloedema may precede ophthalmoscopic signs of optic atrophy in some cases when an intracranial neoplasm presses directly or indirectly on the chiasma or optic nerve. This is the case in tumours and cysts of the pituitary gland and Rathke's pouch, glioma of the chiasma and intracranial part of the optic nerve. Prognosis as regards vision, after the raised intracranial pressure has been reduced surgically, depends upon the degree of papilloedema and its duration and on the intracranial state of the optic nerves, chiasma and tracts, considerable stretching, compression or erosion militating against recovery. A haemangioma of the occipital cortex is sometimes made evident by X-ray examination of the skull on account of calcareous deposits in the walls of the vascular spaces of the neoplasm. It may be associated with a haemangioma of the same side of the face and the visual fields show defects corresponding to those in the occipital cortex.

9.–DISEASES OF THE OCULAR ADNEXA

Sinusitis

157.] Some authorities hold that posterior ethmoidal and sphenoidal sinusitis may cause optic neuritis and subsequent optic atrophy as a result of compression and infiltration of the optic nerve with inflammatory fluid and cells, the periosteum of the optic canal and medial wall of the apex of the orbit being the site of inflammation. Other observers doubt this.

Hyperostosis

Hyperostosis of the optic foramen may compress the optic nerve. A good radiogram will reveal any pathological changes. Decompression by removal of part of the roof of the optic canal has been attempted by some surgeons.

Oxycephaly

The developmental defects which lead to oxycephaly result in the middle fossa being on a much lower level than normal, with the result that the optic nerves are kinked in passing through the optic canal entrance on the intracranial side and are in some instances compressed against the lower margin of the canal at this site; this would account for the characteristic defect in the upper part of the visual field. Optic atrophy is associated with this condition.

10.—REFRACTIVE ERRORS

Myopia

158.] In high degrees of myopia the choroid and retina are considerably stretched and show areas of degeneration in the region of the macula and optic disc. Ophthalmoscopically there are irregularly-shaped white areas of sclera showing through the atrophic choroid, fringed by irregular-shaped pigment deposits and traversed by retinal veins running through the thin and atrophic retina. Haemorrhages in the choroid occur in some cases. Pigmentary disturbance at the macula is a complication which may precede degeneration. Optic atrophy and atrophic cupping of the optic disc are late events. Vitreous degeneration is manifested in increased fluidity of this structure and a breakdown of its fibrillar structure into irregular-shaped strands of floating opacities. Retinal detachment is a complication, but affects the moderate degrees more often than the high degrees of myopia. Cataract from malnutrition of the lens is another complication of myopia. Owing to the increased length of the eyeball the eyes are prominent, especially in the high degrees of myopia.

Treatment

Careful attention to the principles of ophthalmic hygiene as regards posture, lighting and print when engaged in near work is essential. Lenses which fully correct the refractive error should be worn constantly in all except very slight cases of myopia under 0·75 diopter. School work may have to be specially regulated in cases of progressive myopia in children and suitable occupation found for adolescents and adults. There is some clinical evidence that calcium may assist in arresting the progress of myopia in children, but further work to substantiate this is necessary. Needling of the lens is indicated only in cases of over 15 diopters in young persons with a normal fundus; it is then advisable to operate on one eye only. Curette evacuation of soft lens matter after needling should not be performed unless there is a rise of intra-ocular pressure. Retinal detachment when a hole or tear in the retina is found may be treated by surgical diathermy. This method is designed to produce a choroiditis over the site of the retinal tear and, after drainage of the interretinal (subretinal) fluid through a scleral trephine hole, to establish choroido-retinal adhesions, and by occluding the retinal tear to prevent the passage of fluid from the vitreous into the interretinal space. The results of this treatment vary with the duration and extent of the detachment, the state of the vitreous, the degree of myopia, the number of holes and other factors.

For *Keratoconus* (*conical cornea*), see page 412.

Irregular astigmatism

Vision may be considerably impaired by irregularities in the curvature of the cornea and lens surfaces which cannot be corrected by cylindrical lenses. Corneal nebulae and lens opacities may be responsible for these irregularities in some cases. Alterations in the refractive indices of the transparent media of the eye, particularly the vitreous, may also cause a considerable reduction in visual acuity.

11.–GLAUCOMA

(1)—Primary Glaucoma

159.] Glaucoma is the term applied to a complex group of conditions the distinctive feature of which is a rise of intra-ocular pressure. For clinical convenience glaucoma is classified as primary and secondary, and either of these groups may culminate in acute congestive manifestations, or progress in an insidious chronic state from the initial symptoms and signs to the final stages of absolute blindness and pain. An intermediate stage between the acute and chronic stages is described by some authors as 'subacute', but as such is within the fluctuating bounds of this disease and does not merit a separate label of classification.

Aetiology

The cause is still unknown. Such factors as the equilibrium between the production and drainage of the aqueous fluid, the intra-ocular blood-pressure and blood-volume, the physical state of the vitreous, the increasing size of the lens with advancing years, the distensibility of the cornea and sclera, the presence of an H-substance in the aqueous of some acute glaucomatous eyes, the altered permeability of the capillaries of the iris and ciliary body, and the mechanical narrowing or occlusion of the filtration angle from forward displacement of the iris root and swelling of the ciliary body are concerned in the aetiology of the disease.

Symptoms

The symptoms may range from a severe neuralgic headache and pain in the affected eye, with vomiting, collapse, and loss of vision such as characterizes an acute congestive attack of glaucoma, to the transient headaches, blurred vision, rainbow rings and flashes of light of short duration (one hour or so) that are a feature of chronic glaucoma. The disease may be even more insidious so that the patient fails to appreciate the fact that anything is amiss. A careful investigation of the visual fields and Schiötz tonometer readings should be made in any patient over forty years of age suffering from headaches which are unrelieved by correcting the refractive error. Hereditary and familial influences are evident in some cases. Epidemic glaucoma has been described in certain Indian clinics and is due to temporary oedema of the uveal tract.

Acute congestive glaucoma

The signs of acute congestive glaucoma are a uniform corneal haze due to oedema of the epithelium and substantia propria, a shallow anterior chamber, a semi-dilated, inactive, oval pupil with its long axis set obliquely; on palpation the globe has a stony hardness; the conjunctival and ciliary vessels are congested and there is slight oedema of the lids. Vision is reduced to hand movements, counting fingers, or perception of light only. Vomiting and collapse accompany severe cases.

Chronic glaucoma

The signs of chronic glaucoma are more insidious and transitory. Attacks of neuralgic pain in the eyes, and referred to the frontal, temporal and malar regions come on at certain times of day, commonly on rising in the morning, passing off when the patient has moved about for an hour or so to return again in the evening between five and seven o'clock. Attacks are sometimes associated with worry, emotional stress, exposure to cold and hunger. Accompanying the pain the vision is blurred, coloured rings and haloes are seen around lights at night time, flashes of light, sometimes blue and red, are also observed. Defects in the visual field become evident after several attacks, there being a loss first on the nasal side and enlargement of the blind spot. Later symptoms are concentric contraction of the periphery of the visual field, a paracentral scotoma, and eventually loss of fixation and reduction of the field to a small area in the temporal field and finally total blindness. Using a Schiötz tonometer the intra-ocular pressure is normally between 18 and 25 mm. Hg, but in glaucoma it may be raised above this level.

Treatment

Treatment of the acute congestive type of glaucoma must be prompt. Instillation of 1 per cent eserine sulphate solution into the affected eye every five minutes for half an hour, and then hourly, should be combined with medical diathermy (300 to 500 milliamperes for 5 minutes) or heat in some form, and leeches to the temporal region. Rest in bed, calomel and salines are appropriate. Intravenous hypertonic saline, 50 c.c. of 30 per cent saline, will reduce the intra-ocular pressure for twenty-four hours or so. When the intra-ocular pressure is reduced to 30–40 mm. Hg it may be safe to operate. An iridectomy or a trephine operation may be selected, depending on the history and nature of the case. Eserine should also be instilled into the unaffected eye.

For chronic glaucoma with no field changes a miotic such as 0·5 per cent pilocarpine nitrate or 0·5 per cent eserine sulphate may be tried for a time. Should the intra-ocular pressure not be maintained within normal limits with these drugs an operation is advisable. The trephine operation is generally selected.

Excision becomes necessary for a blind painful eye from absolute glaucoma.

(2)—Secondary Glaucoma

Aetiology

Many of the causes of secondary glaucoma have been dealt with elsewhere in this classification. Any condition which causes mechanical occlusion of the filtration angle may give rise to secondary glaucoma. A few instances are as follows: pus, blood, soft lens matter and inflammatory fluid with a high colloid content present in the anterior chamber; adhesions between the iris root and the back of the cornea and complete ring-synechia at the pupil margin obstructing the flow of aqueous into the anterior chamber and thereby causing iris bombé; swelling and dislocation of the lens; cyclitis; neoplasms pushing the vitreous, lens and iris forwards; moderate or large intra-ocular haemorrhage; rarely detachment of the retina.

Treatment

Treatment of the condition causing glaucoma is indicated. In some cases recourse to surgery becomes necessary, such as paracentesis, anterior chamber wash-out evacuating pus, blood or soft lens matter, iridotomy or iridectomy for iris bombé and peripheral synechiae, and excision of an eye for a malignant tumour.

(3)—Buphthalmos (Congenital Glaucoma)

Congenital defects in the formation of the filtration angle, such as failure of a complete line of cleavage between the iris root and the posterior surface of the cornea, absence or maldevelopment of the canal of Schlemm, and structural anomalies of the ligamentum pectinatum may cause defective drainage of aqueous. The cornea and sclera of a young person's eye are readily stretched and so the eye becomes large and the corneal diameter increased. The cornea is thicker in the centre than at the periphery and there are sometimes splits in Descemet's membrane; the anterior chamber is deep; the iris flattened and atrophic; ectropion uveae is present in advanced cases and the pupil semi-dilated and sluggishly active. The lens is displaced posteriorly and its anterior surface considerably flattened; the sclera, choroid and retina are thinner than normal and show evidence of atrophy; the optic disc is cupped and the optic nerve becomes atrophic. One or both eyes may be affected. Loss of perception of light is a terminal event.

Treatment

Operative treatment such as trephining, and Herbert's anterior sclerotomy are rarely effective in arresting the progress of the disease.

12.—CATARACT

160.] A number of pathological conditions may cause physical and chemical changes in the lens fibres rendering them opaque or inducing metaplasia of the epithelial cells of the anterior lens capsule. The symptoms are at first black spots seen by the affected eye, uniocular polyopia and gradual deterioration of vision.

(1)—Congenital Cataract

Anterior polar cataract

Anterior polar cataract affecting the anterior layers of the foetal cortex and the capsule is caused by prolonged contact of the lens with the posterior surface of the normal cornea in delayed formation of the anterior chamber, or with an inflamed cornea. It is also produced by a perforating corneal ulcer in ophthalmia neonatorum. In the congenital form it is almost always bilateral whereas in the acquired form it is generally unilateral. The opacity is in the anterior capsular epithelium, but the underlying anterior cortical fibres may also show a localized opacity. Pyramidal cataract is due to the dragging forward of the anterior capsular cataract by an adhesion which usually breaks and rarely persists.

Posterior polar cataract

Posterior polar cataract is not a cataract in the true sense but is caused by congenital defects in the posterior lens capsule and a persistence of part of the hyaloid vascular sheath.

Lamellar cataract

In lamellar cataract the opacities are situated in the layers surrounding the nucleus, which itself contains punctate opacities. With a dilated pupil the centre of the lens appears as a grey disc surrounded by a clear transparent marginal zone. Around the periphery of the grey disc a few spindle-shaped opacities are present between the lens fibres in layers a short distance outside the main opacity and form what are known as 'riders'. The cataract is usually stationary until late in life, but some cases gradually develop total opacity. Lamellar cataract is due to a period of malnutrition at some stage of late intra-uterine or early infantile life. Defective enamel in the form of transverse lines of erosion in the incisor and canine teeth is associated with lamellar cataract.

Treatment

For the first nine to ten months of life the pupils should be kept dilated with atropine ointment (0·5 per cent) on alternate days. This procedure keeps the retina stimulated by light passing through the clear periphery of the lens and obviates the occurrence of nystagmus and squint.

If the vision is not worse than 6/18 it is wise not to operate. For cases in which the visual acuity is less than this needling is indicated, and the patient should be fitted with glasses for distance, and a separate pair for near work, as there is no accommodation in an aphakic eye.

Other types of cataract

Other types of congenital cataract are central or nuclear cataract; fusiform cataract; discoid cataract, a familial form in which the cataract is situated just behind the nucleus in the posterior cortex; and punctate cataract.

Most of these are stationary but some progress to total cataract. Other congenital stigmata such as nystagmus and colobomas may be associated.

Treatment

Some cases do not require any treatment, others require optical iridectomy at puberty, or discission. Needling is justified at an age earlier than nine to ten months if the cataract is total and there are signs of squint or nystagmus developing, though there is some risk in this procedure.

(2)—Traumatic Cataract

Traumatic cataract is produced by damage to the lens capsule which is torn or ruptured by concussion or a perforating wound, with or without retention of a foreign body. A few hours after the injury the lens becomes cloudy in the vicinity of the wound. A rosette-like opacity in the posterior cortex is typical of traumatic cataract and occurs irrespective of the site of the wound. Occasionally the site of the injury becomes closed by an iris synechia and the opacity remains localized.

Treatment

Full dilatation of the pupil with atropine is essential. Absorption of soft opaque lens matter takes place in young persons, but in adults curette evacuation of the opaque lens substance and subsequent capsulotomy may be necessary.

Iritis and secondary glaucoma are complications to be kept in mind.

(3)—Senile Cataract

In cases in which the opacities are limited to the centre of the lens and the visual axis, attempts to improve the vision may be made by wearing dark glasses and using weak solutions of atropine sulphate, $\frac{1}{8}$ grain in 1 fluid ounce, to produce dilatation of the pupil and utilize the clear periphery of the lens. This should be used with caution on account of inducing a rise of intra-ocular pressure in an elderly subject. Atropine is definitely contra-indicated in cases in which the intra-ocular pressure is above normal, in cases of hypermetropia, small corneae and shallow anterior chambers.

An iridectomy may be of some help in a few selected cases. In other cases, when the vision is below 6/18 in both eyes or as soon as the cataract is mature, extraction is indicated.

(4)—Complicated Cataract

Aetiology

Complicated cataract arises as a result of disturbed nutrition of the lens. Iridocyclitis, choroido-retinitis, pigmentary degeneration of the retina, high myopia, suppurative keratitis, glaucoma, retinal detachment and direct pressure from neoplasms in the vicinity of the lens are among the commonest causes.

At first the changes are in the posterior cortex of the lens; later they affect the anterior cortex close to the nucleus and finally involve the whole cortex.

Treatment

In the case of an inflammatory ocular lesion no operative treatment should be undertaken for at least a year after the disease is quiescent. Preliminary iridectomy followed by extraction is the safer course.

(5)—Cataract due to Endocrine Disorders

(*a*) *Diabetes mellitus*

A uniform milky opacity of rapid onset should always suggest the possibility of diabetes mellitus. The cause is unknown, but it is probably due to some deleterious agent in the lymph secreted by the ciliary body.

Treatment

Treatment should be directed towards the diabetes. In some cases improvement of vision occurs from medical treatment.

The dangers and complications in undertaking an operation for extraction of the lens are several. Intra-ocular haemorrhage from the iris and the choroid and blood in the vitreous may seriously damage the vision. A peculiarly violent iritis and panophthalmitis may supervene during the post-operative period. It is advisable to do a simple cataract extraction without an iridectomy whenever possible.

(*b*) *Parathyroid Deficiency*

Cataract may also develop as a result of parathyroid deficiency, particularly after a thyroidectomy in which the parathyroids have been excised or damaged.

(6)—Other Causes of Cataract

Lens opacities are also to be found in mongolian idiocy about puberty and in myotonia atrophica between twenty and forty.

Certain workmen such as glass-blowers, particularly makers of beer bottles and plate glass, furnace workers, and iron workers, especially tin-plate millmen, and chain-makers suffer from a characteristic form of cataract which begins as a small opaque disc in the posterior cortex and is probably due to heat irradiation affecting the pigment epithelium of the iris, ciliary body, and retina. *Industrial causes*

Posterior cortical opacities also occur two to eight years after exposure of the region of the eye to X-rays or radium. It is probable that these therapeutic agents in some way damage the capillaries of the ciliary body. *X-rays and radium*

13.–DISEASES DUE TO NUTRITIONAL DEFICIENCIES

161.] Xerophthalmia (xerosis) occurs as a result of a deficiency of vitamin A in the diet. The local causes of xerophthalmia are described under the heading Inflammation (p. 420). The majority of cases are children who do not appear to be under-nourished. It is accompanied by night-blindness and is characterized by small triangular patches on the outer and inner sides of the cornea covered by material resembling dried foam which is due to heaped-up layers of horny epithelium. These areas are not wetted by tears. In marasmic children a severe form of the disease may be found associated with keratomalacia and necrosis of the cornea. *Xerophthalmia*

General treatment consists in ordering a suitable diet containing cod- or halibut-liver oil, milk and butter. Local treatment is directed towards the relief of the conjunctival dryness by weak alkaline solutions and drops of liquid paraffin. *Treatment*

Keratomalacia attacks badly nourished children and is due to absence of fat-soluble vitamin A in the diet. Dryness and xerotic spots appear in the conjunctiva. The cornea becomes dull and insensitive, yellow infiltrate forms in its substance and finally extensive necrosis may occur in a few hours. There is a characteristic absence of inflammatory reaction. *Keratomalacia*

An adequate supply of vitamin A is given in the diet. Cod-liver oil should be rubbed into the skin if the patient is too ill to take it by the mouth; and halibut-liver oil or other concentrated preparations containing vitamin A (e.g. adexolin, radiostoleum) may be administered. Subcutaneous injections of physiological saline are also beneficial. Local treatment is directed towards protecting the cornea by warm moist compresses applied over the closed lids. Eserine is sometimes of value in improving the corneal nutrition. *Treatment*

Night-blindness is the commonest symptom of scurvy in the adult. Conjunctivitis and corneal ulcers occur. Retinal haemorrhages are very small and rarely seen. *Scurvy*

14.–POISONS

162.] Certain drugs and chemicals acting through the circulation may damage the ganglion cells and nerve fibres of the retina or by their effect on the blood-vessels interfere with its nutrition.

Tobacco

Tobacco amblyopia affects men between thirty-five and fifty-five years of age who are pipe smokers or who chew shag or mixtures. Tobacco dust in factories and snuff-taking sometimes cause this disorder. Twenty or more years of hard smoking elapse before the onset of symptoms. Alcoholics and diabetics are more liable to be affected. Dimness of vision is complained of. The fundus is normal in appearance. Central vision is seriously impaired. A central or paracentral scotoma for red and green, oval in shape, is situated between the macula and the fixation spot. The scotoma may be absolute in some cases. The papillo-macular bundle of nerve fibres is chiefly affected. It is probable that the more volatile decomposition products of nicotine, e.g. the pyridine bases collidine ($C_8H_{11}N$) and lutidine (C_7H_9N), damage the ganglion cells of the fovea and macular region.

Treatment consists in total abstinence from tobacco and alcohol. Recovery takes place in several weeks in the majority of cases. Tonics containing strychnine, copious draughts of water and exercise are efficacious. Potassium iodide is also recommended.

Alcohol

Ethyl and methyl alcohol may impair vision. In the early stages there is a relative central scotoma for red and green; sometimes this becomes absolute. Complete and partial peripheral defects for red and green may occur. Alcoholic optic neuritis seldom leads to complete blindness.

Methyl alcohol

In the case of methyl alcohol the onset of blindness is sudden and accompanied by abdominal pain and paralysis of certain extra-ocular muscles causing diplopia and ptosis. Headaches, dizziness, cardiac weakness, slow pulse, delirium, convulsions, stupor and death may also enter the clinical picture. The retinal vessels become much reduced in size and optic atrophy sets in later. Ziegler stated that one teaspoonful of methyl alcohol has been known to produce blindness, and an ounce to cause death.

Inhalation of the fumes of materials dissolved in wood alcohol may also cause blindness and death.

Vision may improve temporarily in some cases, but relapses occur and eventually sight is lost by progressive optic atrophy.

Quinine

Such small doses of quinine as 12 grains may cause blindness in susceptible persons. The pupils become dilated and immobile, deafness and tinnitus aurium are present. The retinal vessels are very contracted and the optic disc extremely pale. Oedema of the retina has been described in the early stages. The visual fields are contracted and although improvement takes place later they never regain their normal limits. Central vision may be restored in some cases but in others blindness is permanent and optic atrophy ensues.

The effect of large doses of salicylates is similar to that of quinine but less severe in degree and probably never permanent. Recovery is more rapid and complete than in quinine blindness. Treatment consists in discontinuing the drug, administering amyl nitrite or nitroglycerin, supplemented by strychnine and digitalis. *Salicylic acid and salicylates*

In lead poisoning it is unusual to find eye symptoms and signs without other evidence of chronic plumbism being present. De Schweinitz described the following types of ocular lesion: (1) Transient amblyopia without ophthalmoscopic change may be due to the anaesthetic effect of the lead on the retina and optic nerve. The onset and recovery are rapid and complete, the duration being only a few days. (2) Permanent amblyopia without distinct fundus change, or at most slight hyperaemia of the papilla and fullness of the retinal vessels. This type may terminate in blindness from optic atrophy. (3) Optic neuritis or neuro-retinitis. (4) Optic atrophy. (5) Retinitis due to lead nephritis appearing in the form of vasculitis and perivasculitis. *Lead*

Subjective colour sensations and various forms and degrees of colour blindness are met with. The visual fields may be concentrically constricted; peripheral scotomas, central scotoma typical of toxic amblyopia have been described in the literature. Weakness of accommodation, nystagmus and paralysis of extra-ocular muscles, especially the external rectus, occur.

Prognosis depends upon the stage to which the disease has progressed and the condition of the optic disc.

Treatment consists in removal of the drug and improving the constitutional condition along general medical lines.

Arsenic administered in the form of pentavalent benzene-ring compounds, such as atoxyl, arsacetin and hectine, is especially liable to cause optic atrophy. The members of the salvarsan group have the arsenic in trivalent combination and are less liable to cause blindness. *Arsenic*

Wide dilatation of the pupil, amblyopia and severe retinitis have been reported following the use of ethylhydrocupreine (optochin). Recovery has followed on ceasing its administration. *Optochin*

Cases of blindness have been reported after a dose of 3 grams of extract of aspidium (filix mas), given daily for twelve consecutive days. The symptoms are violent gastro-enteritis, circulatory depression and loss of sight in twenty-four hours to twelve days after the administration of the drug. Ophthalmoscopic appearances have been described as normal by some observers; optic atrophy has been noted by others, and one reported case showed retinal oedema, thread-like arteries, broken blood column and tortuous veins filled with broad and very dark columns of blood. *Filix mas*

Iodoform taken by mouth or used externally in the form of dressings has caused amblyopia and loss of central vision. The visual fields are full and there are no ophthalmoscopic changes. Recovery is usual after cessation of the drug. *Iodoform*

Toxaemia and amblyopia may be caused by the inhalation of carbon

Carbon bisulphide bisulphide. The symptoms are heavy pain in the forehead and temples, exaltation of spirits and temporary visual defect coming on towards the end of the day. At a late stage depression, anorexia, insomnia and blurred vision in broad daylight occur. Pallor of the discs, slight neuritis, partial or complete atrophy and normal discs have been described. The central visual acuity is considerably lowered, the scotoma being more marked for red and green. The peripheral fields are complete.

Nitrobenzene Nitrobenzene may gain entrance to the body through the lungs in the form of fumes and fine dust and also through the skin. The general symptoms include headaches, muscular weakness, cyanosis, rapid shallow respiration and a thready pulse. Central vision is diminished, the visual fields contracted, and there is sometimes a colour scotoma. The pupils are dilated, the fundus has a dark colour; venous hyperaemia, dark tortuous full veins and pallor of the discs with slightly blurred margins are the ocular signs. The prognosis is good if the patient is removed from access to the poison.

Aniline The symptoms of aniline poisoning are similar to those of nitrobenzene poisoning. In addition intense pigmentation of the cornea and conjunctiva may occur.

Antipyrin Antipyrin has caused temporary blindness in a few cases. The discs become pale and the vessels narrow. Recovery is generally complete.

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BLOOD EXAMINATION

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I.—CELLULAR CHANGES

(BLOOD COUNT)

Preliminary examination

163.] The preliminary investigation of a case of anaemia is usually confined to a simple blood count, that is, an estimation of haemoglobin, enumeration of red cells and calculation of colour index, enumeration of leucocytes (total and differential) and an examination of the blood film for abnormal red cells. This examination provides a pointer for recognizing the type of anaemia and should indicate whether more elaborate investigations are required. Facts of diagnostic and prognostic significance are often indicated by minor changes in the cellular content of the peripheral blood. But the interpretation of minor changes requires experience. Such changes are rarely specific, and if divorced from a competent clinical examination may easily be misinterpreted. Apart from frank leukaemia, gross agranulocytosis, and the presence of blood parasites, pathognomonic blood changes are comparatively rare; even the blood picture of pernicious anaemia may be closely simulated by other diseases. A blood examination should be regarded as an integral part of a complete clinical examination, and must be assessed in the same manner as any other clinical sign.

If the blood examination is carried out by a laboratory, a note of all relevant clinical details, the age of the patient and the probable diagnosis should accompany the specimen; no reasonable comment can be made on the blood findings in the absence of this information. The elucidation of the cause of the type of an anaemia may require elaborate investigations, not only of the blood, but also of other systems, especially the gastro-intestinal tract, the nervous system, the skeleton, and bile pigments. From the haematological aspect the facts of a simple blood count may have to be supplemented by a determination of red-cell size, a reticulocyte count, a platelet count, coagulation factors, bilirubinaemia, the response to treatment, and the volume occupied by the corpuscles in a centrifugalized sample of a standard amount of blood. When the last-named examination is combined with the haemoglobin estimation and red-cell count, there can be determined the volume index and saturation index, as well as the absolute values known as the mean corpuscular volume, the mean corpuscular haemoglobin, and the mean corpuscular haemoglobin concentration.

Scope of haematological examinations

Many of the more elaborate procedures require access to a laboratory; they cannot be performed on samples taken by anyone but a trained haematologist, or on samples which are subjected to delay in transit. But the taking of a sample for a simple blood count is within the scope of general practice, and the result of such a count will often supply valuable evidence for excluding a given disease, for indicating a possible diagnosis, for explaining a symptom, for estimating prognosis, or for indicating that the patient merits a fuller investigation by a well-equipped laboratory.

1.–METHODS OF COLLECTING THE SPECIMEN WHEN SENDING BLOOD TO THE LABORATORY

First method

Obtain a sample of blood by venepuncture and collect this in a tube containing a suitable quantity of potassium oxalate. Small corked tubes to hold 5 c.c. of blood are required. Each tube contains 2 mgm. of dry potassium oxalate per c.c. of blood. The tubes are prepared by measuring into a 5 c.c. tube exactly 0·5 c.c. of a 2 per cent solution of potassium oxalate. The fluid is then evaporated to dryness in a drying oven. Blood is obtained by venepuncture without using a tourniquet, and exactly 5 c.c. are immediately emptied into the tube. The tube is corked and well shaken. The specimen should then be sent to a laboratory with the minimum of delay. The following are the maximum times which may elapse between the taking of the blood and the performance of the count if an accurate result is to be obtained:

Haemoglobin estimation	24 hours
Red cells	24 ,,
Leucocytes	24 ,,
Blood platelets	1 hour
Icterus index	4 hours
Van den Bergh reaction	4 ,,
Fragility of the red cells	3 ,,
Sedimentation test	3 ,,
Corpuscular volume	3 ,,

These times vary with the weather and are shorter when the temperature is high. Blood films made from oxalated blood are not satisfactory for a differential count. Blood films should be made from another finger-prick (p. 466). These are allowed to dry, wrapped in paper, and sent to the laboratory.

Second method

Obtaining blood

A second method is as follows: Two small bottles with glass stoppers are taken, containing, respectively, a small amount of distilled water, and 2 c.c. of the diluting fluid for red cells (p. 462). With a 20 c.mm. pipette 20 c.mm. of blood, obtained from a finger-prick, are added to each bottle. The bottles are then well shaken. Blood films are made at the same time. On receipt at the laboratory the haemoglobin is estimated in the usual manner, the red cells are counted reckoning the dilution as 1 in 100, and the leucocytes in about six successive preparations are also enumerated.

2.–STANDARD TECHNIQUE FOR BLOOD COUNT

Apparatus.—Haemoglobin 20 c.mm. pipette with standard tube (see p. 461), red-cell and leucocyte pipettes, diluting fluids, mouth-piece and rubber tubing, clean slides, needle, alcohol, cotton-wool.

Blood is obtained by pricking either the ball of the finger, the edge of the nail-bed, lobe of the ear, ball of the thumb, or the great toe or heel, the last two especially in infants. Clean the site with alcohol, dry thoroughly, puncture boldly, preferably with a bayonet-pointed needle. If the blood does not flow freely, traction (not pressure) may be exerted on the sides of the wound. The operation of filling the pipettes should occupy not more than a minute. It is essential to have all apparatus ready before beginning, and to use a long rubber tube—most of the tubing supplied with apparatus is far too short.

3.–HAEMOGLOBIN DETERMINATION

Sahli's method

In Sahli's method the haemoglobin contained in a known quantity of blood is converted into acid haematin by means of hydrochloric acid. The colour is then compared with a standard tube containing acid haematin of known strength. The apparatus consists of a blood pipette of 20 c.mm. capacity, a sealed comparison tube containing the standard acid haematin solution, a graduated tube of the same diameter, and a black comparator frame with a white background in which the tubes may be compared. Into the graduated tube is placed decinormal HCl up to the mark 10. The pipette is filled with blood to a point just above the 20 c.mm. mark and the point of the pipette is then wiped or dabbed on a piece of filter paper until the blood stands exactly at the 20 c.mm. mark. The contents are then blown into the HCl and the pipette washed out by alternately sucking the acid in and out. The blood turns brown owing to the formation of acid haematin. Complete conversion into acid haematin takes thirty to forty minutes. Distilled water is now added drop by drop and the contents of the tube mixed between each addition by closing the tube with the finger and inverting. Care should be taken that no appreciable amount of fluid remains on the finger. Distilled water should be added until the colour as seen in the comparator is exactly the same as the standard. The standard should be checked every six months as the colour is liable to fade. In order to avoid fading, sealed standards made of non-fading coloured glass can be obtained, but unfortunately the colour is usually not exactly the same tint as that obtained with blood. The normal findings by Sahli's method are 90 per cent for males and 80 per cent for females. The Sahli 100 per cent is equivalent to 17·3 grams of haemoglobin per 100 c.c. of blood.

Haldane's method

The principle of Haldane's method is to convert the haemoglobin of a known volume of blood into carboxyhaemoglobin and to compare the colour with a standard tube of the same size containing carboxyhaemoglobin. The test is made in a tube graduated like the Sahli tube. Distilled water is placed in the graduated tube up to the 20 per cent mark and 20 c.mm. of blood added to it in the manner already described. A fine glass tube is attached by means of rubber tubing to a gas tap and introduced into the graduated tube near to the level of the laked blood. The coal gas is allowed to saturate the haemoglobin solution for a period of five minutes. Distilled water is added drop by drop in the manner described for Sahli's test until the fluid is the same colour as the standard when compared either in a comparator box or against a white background, such as a sheet of paper. With the latter method, the light should come over the observer's shoulder. Matching in artificial light is difficult. Haldane's 100 per cent is equivalent to 13·8 grams of haemoglobin per 100 c.c. of blood. The normal for a male is 115 per cent and for a woman it is 100 per cent.

Comparison of Normal Values

(1) Adults:

Normals and equivalents in adults

HAEMOGLOBIN	MAN	WOMAN
Grams per cent – –	15·8	13·8
Haldane per cent – –	115	100
Sahli per cent – –	90	80

In infants

(2) Infants.—At birth the haemoglobin is usually about 140 per cent (Haldane); this declines during the first three months of life to approximately 75 per cent (Haldane) but should rise again to attain ordinary adult level sometime in the second year.

Averages of the figures for adults are made use of for calculating the colour index and other indices (p. 471).

4.–ENUMERATION OF RED CORPUSCLES

Collection of blood

The red-cell pipette is graduated to give a blood dilution of 1 in 100 or 1 in 200. The stem of the pipette is marked with the figures 0·5 and 1, and the top of the pipette is marked with the figure 101. Blood from the finger puncture is sucked into the pipette to the 0·5 mark, or to the 1 mark if the patient is very anaemic. The tip of the pipette is then wiped and dipped into the red-cell diluting fluid. The fluid is *gently* sucked up to the 101 mark. The mouth-piece is now detached, the ends of the pipette sealed with the fingers and the contents thoroughly mixed with a twisting motion. Mixing is assisted by means of a bead contained in the bulb of the pipette, and this bead is sometimes coloured red in order that the red-cell pipette may be readily distinguished from the leucocyte pipette. If the blood has to be carried to a distance, the ends of the pipette may be sealed by two rubber caps or by a flat rubber band. If the count is not performed immediately, the contents of the bulb must be mixed thoroughly before a drop is taken out for counting purposes. After filling the pipette it will be noted that the capillary end is occupied entirely by diluting fluid and hence the true dilution of the cells is not 0·5 (or 1) in 101, but 0·5 (or 1) in 100, i.e. 1 in 200 (or 1 in 100). For all ordinary purposes the 1 in 200 dilution is used.

Diluting fluids

Diluting Fluids for the Red Cells.—The following are commonly used:

(1)

Sodium chloride – – –	0·6 gram
Sodium citrate – – –	1·0 gram
Solution of formaldehyde –	1·0 c.c.
Distilled water – –	to 100 c.c.

(2) *Hayem's solution:*

Sodium chloride – – –	1 gram
Sodium sulphate – – –	5 grams
Mercuric chloride – –	0·5 gram
Distilled water – –	to 200 c.c.

(3) *Toison's fluid:*

Sodium sulphate – – –	8 grams
Sodium chloride – – –	1 gram
Methyl violet – – –	0·025 gram
Glycerin – – –	30 c.c.
Distilled water – – –	160 c.c.

Counting

Counting is performed on a haemocytometer of known capacity. The counting chamber and the special thick cover-slip supplied with it are cleaned, and the cover-slip is placed centrally over the bar of the counting chamber. The fluid in the pipette is thoroughly mixed and about one-third of the contents of the bulb are blown out and discarded. The pipette is then held at an angle of about 45 degrees, the tip being made to touch the space between the cover-slip and the counting slab. The fluid will run under the cover-slip by capillary attraction. Bubbles must be avoided and the fluid should just fill the space under the cover-slip between the two grooves. If the fluid overflows from the counting slab, the apparatus should be cleaned and the operation repeated. The same principles apply when the counting slab is a central circular pillar instead of the more convenient bar. Small bubbles may be got rid of by gently easing the cover-slip in a sideways direction and bringing them to the edge of the counting slab.

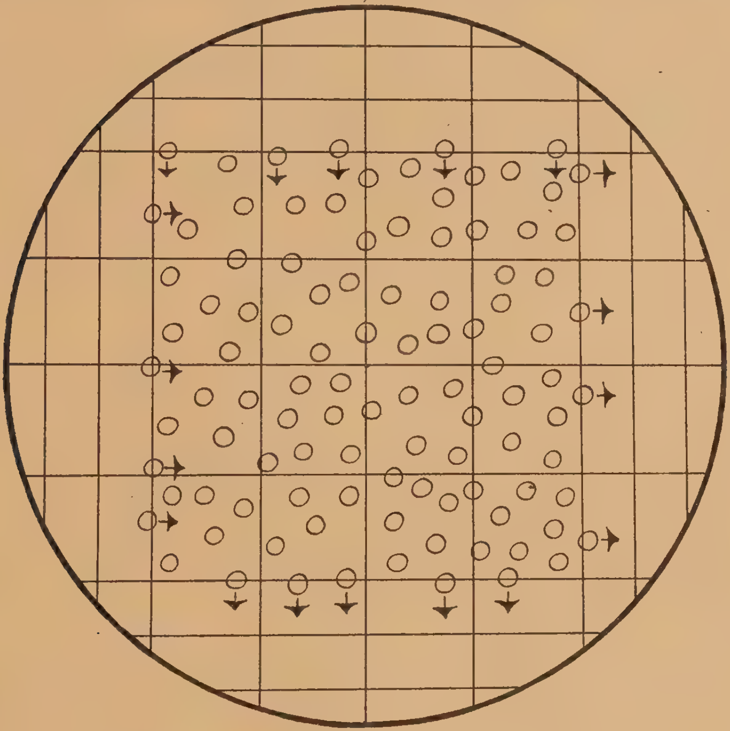


FIG. 72.—Thoma ruling with $\frac{1}{6}''$ lens to show which cells should be counted and which neglected. (From *Disorders of the Blood*, by Whitby and Britton)

The corpuscles must be allowed to settle for at least three minutes. The light entering the microscope is cut down by partly closing the diaphragm and the preparation is examined with the low power in order to see that the cells are evenly distributed; if they are not, another preparation should be made. Counting is performed with the $\frac{1}{6}''$ lens.

Thoma ruling

As a routine, with the Thoma ruling, the corpuscles contained in eighty small squares should be counted. All the corpuscles which touch the left-hand line or the upper line of a square are counted as being in that square; those which touch the lower or right-hand lines are counted as outside the square (see Fig. 72). If the dilution is 1 in 200 the addition of four noughts to the total number of cells counted in eighty squares gives the number of corpuscles in 1 c.mm. of whole blood when using the Thoma ruling; if the dilution is 1 in 100 the figure so obtained must be halved. The eighty small squares which are counted should comprise five blocks of sixteen small squares and these should be distributed over the whole counting chamber, it being usual to take one block of sixteen from each corner and one from the centre. The addition of four noughts to the total number of cells in eighty small squares is only permissible with the Thoma ruling which consists of 1 square millimetre ruled so that the larger squares between the treble lines contain sixteen small squares, each small square having a side of $\frac{1}{20}$ mm. or an area of $\frac{1}{400}$ sq. mm. The cover-slip supplied with the apparatus is specially ground and is of such a weight and size that the depth of the fluid beneath it is exactly $\frac{1}{10}$ mm. The volume of each small square is therefore $\frac{1}{400} \times \frac{1}{10} = \frac{1}{4{,}000}$ c.mm. The volume of eighty small squares is $\frac{80}{4{,}000}$ c.mm. If the dilution of the blood is 1 in 200, the actual volume of whole blood counted is $\frac{80}{4{,}000 \times 200}$ c.mm.—i.e. $\frac{1}{10{,}000}$ c.mm. The number of cells contained in eighty small squares multiplied by 10,000 therefore represents the number of cells per cubic millimetre of whole blood.

Neubauer ruling

The Neubauer ruling is now more commonly used. With this there are no triple lines but only thin double-ruled boundary lines to indicate the margins of each block of sixteen small squares. As with the Thoma ruling the corpuscles in eighty small squares (or five blocks of sixteen) are counted.

Normal counts

The average red-cell count of a male is 5,500,000 per c.mm. with a normal range from 5,100,000 to 6,350,000 per c.mm.; for a female the average is 5,000,000 per c.mm. with a normal range from 3,900,000 to 6,000,000 per c.mm. In new-born infants the red-cell count is 6,500,000 to 7,500,000 per c.mm. For the purpose of the colour index and other indices (p. 472) a figure of 5,000,000 per c.mm. is taken to represent 100 per cent of red cells.

Fluctuations in a red-cell count of as much as ± 5 per cent are of very little significance. Apart from the experimental error allowed even to the most skilled observer, the cell count itself may show physiological fluctuations of this order.

Sources of error

The following are common sources of error:

(1) Blood taken from a cyanosed area. (2) Blood drawn above the

Count above true count

mark in the pipette—a common error if the rubber mouth-piece is too short. (3) Diluting fluid not drawn up to the 101 mark. (4) Using the first drop of blood for filling the pipette. (5) Improper mixing. (6) Uneven distribution in the counting chamber. (7) Cells which touch all sides of the squares included in the count. (8) Yeasts, dirt, and leucocytes (in leukaemia) counted as red cells. (9) Errors in calculation.

Count below true count

(1) Dilution of the blood with tissue juices owing to oedema or to squeezing. (2) Blood not drawn up to the mark in the pipette. (3) Diluting fluid drawn above the 101 mark. (4) Saliva in the mouth-piece causing further dilution. (5) Improper mixing. (6) Uneven distribution in the counting chamber. (7) Cells touching the left-hand and upper lines not counted. (8) Cells lost through haemolysis owing to faulty diluting fluid. (9) Errors in calculation. (10) Using the first drop of fluid from the pipette. (11) Clumping or coagulation of some of the blood; this may be pathological.

The count may also be inaccurate by reason of improperly standardized instruments and bad adjustment of the cover-slip.

5.–CLEANING OF INSTRUMENTS

All apparatus should be cleaned immediately after use. The cover-slip and counting chamber should be washed in distilled water and dried on a piece of clean soft linen. The pipettes should be cleaned by drawing through them distilled water, followed either by acetone or by absolute alcohol followed by ether. The cleansing is most conveniently performed with a suction pump, the end of the pipette being allowed to dip in a vessel containing the appropriate fluid. If a suction pump is not available, the fluids may be sucked into the pipettes, but the final drying fluid should be milked out by alternate compression and relaxation of the rubber tube, otherwise the pipette will be wet from the moisture of the breath. If the pipettes are blocked, a stiff horsehair should be passed through, or, alternatively, they may be stood overnight in concentrated sulphuric acid.

6.–ENUMERATION OF LEUCOCYTES

Technique

The leucocyte pipette is similar to the red-cell pipette except that it is marked 0·5, 1 and 11 and gives dilutions of the blood of 1 in 20 or 1 in 10. The diluting fluid is as follows:

Glacial acetic acid – – – –	1·5 c.c.
1 per cent solution of gentian violet in water –	1·0 c.c.
Distilled water – – –	to 100 c.c.

The glacial acetic acid haemolyses the red cells and the gentian violet slightly stains the nuclei of the leucocytes. The leucocytes may, therefore, be easily recognized. A small quantity of thymol may with advantage be added to the diluting fluid in order to prevent the growth of moulds. The pipette and counting chamber are filled in the same manner as described for the red-cell count.

Counting

All the leucocytes contained in the whole of the cross-ruled area of the Thoma counting chamber should be enumerated. This comprises an area of 1 square mm. and a volume of $\frac{1}{10}$ of a c.mm. The count may be performed either with the $\frac{2}{3}''$ lens with the light well cut down or preferably with the $\frac{1}{6}''$ lens.

At least four preparations should be made and the counts averaged. Certain counting chambers (e.g. Neubauer) are ruled to include several blocks of 1 square mm. so that only one preparation need be examined.

Calculation

The average number of cells in the whole of the ruled area of the counting chamber is the number present in $\frac{1}{10}$ of one cubic millimetre of diluted blood. If the dilution of the blood is 1 in 10, the number of cells per c.mm. of whole blood is found by multiplying this figure by 100. If the dilution be 1 in 20 the figure should be multiplied by 200.

The possible sources of error are the same as for the red-cell count (p. 465). Nucleated red cells, specks of dust, moulds, and fragments of haemolysed red cells may be mistaken for leucocytes by the inexperienced. The stained blood film should give warning of the presence of nucleated red cells in any large numbers.

Normals

In an adult the normal number of circulating leucocytes is from 5,000 to 10,000 per c.mm. Fluctuations within these limits have no significance. Five different types of leucocytes can be differentiated; the distribution of these is given on page 469.

In infancy and childhood both the total number of cells and their distribution are considerably different from the number and distribution in the adult. At birth the leucocytes number about 18,000 per c.mm.; they fall to about 14,000 two days later, then rise almost to the birth level at the end of twelve days; from then onwards during the next twelve years the count falls slowly to the average adult level of 7,500 per c.mm. (Whitby and Britton, 1935).

7.–THE PREPARATION OF STAINED BLOOD FILMS

Blood films may be made on slides or cover-slips. For most purposes slides are preferable but cover-slips are of value for the making of supravital preparations (p. 469). It is essential for the slide to be absolutely clean. A simple and rapid cleaning method for an emergency is to place the slides in glacial acetic acid for a few minutes, wash in distilled water and then in alcohol. Flame the slide and polish with a clean soft handkerchief. Properly spread films are essential for accurate work. The thickness of a good film depends on the examination required. If the red cells are to be examined the film should be so thin that the cells are close together, but do not overlap. For an ordinary differential leucocyte count it is an advantage for the film to be somewhat thicker.

Spreading the film

Apply the narrow edge of a slide to a small drop of blood from the finger or ear. Apply this edge to the surface of a cleaned slide which is lying flat on a firm smooth surface. The blood will now spread along the edge of the 'spreading' slide. With the 'spreading' slide at an angle of about 45 degrees, push the drop of blood steadily along the other slide (see Fig. 73). The thickness of the film may be increased by taking a large drop of blood, by pushing the spreading slide more rapidly or by increasing the angle between the slides. The film should be allowed to dry in the air and should not be heated. Some prefer to use a special 'spreader' instead of an ordinary slide. A 'spreader' consists of a slide that has been cut with a diamond so that its spreading edge is slightly concave; it is also somewhat narrower than the slide on which the film is made.

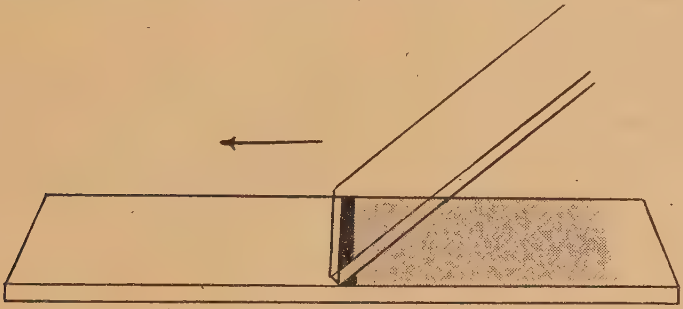


FIG. 73.—Spreading a blood film
(From the Author's *Medical Bacteriology*)

Fixation and staining

The routine blood stains are the Romanowsky stains and most of these are dissolved in absolute methyl alcohol. These stains have, therefore, the power of fixation as well as of staining. Before using other stains, blood films may be fixed by soaking for one or two minutes in pure methyl alcohol.

8.–THE ROMANOWSKY STAINS

These stains depend for their action on the compounds formed by the interaction of methylene blue and eosin. They are used for staining blood films, cellular exudates and specimens containing parasites, such as the plasmodium of malaria. The differences between the various stains are mainly in the proportions of methylene blue and eosin or in the method of treating the methylene blue before it is allowed to combine with the eosin. Small amounts of stain may be conveniently prepared from the 'soloid' tablets marketed by Burroughs, Wellcome & Co. Most of the stains are dissolved in methyl alcohol. After making up the methyl alcohol stains, they should be protected from the water vapour in the air by a well-fitting stopper. Most Romanowsky stains, but especially Leishman's stain, are valueless if any water is present in the methyl alcohol. Tap water should never be used when diluting Romanowsky stains. The most commonly used preparations are Jenner's stain and Leishman's stain.

Jenner's stain

To make Jenner's stain dissolve 0·5 gram of the powdered stain in 100 c.c. of pure methyl alcohol. This stain is used particularly for the cytological examination of blood films.

The blood film is allowed to dry in the air, and is not fixed by heat. Pour the undiluted stain on to the film and allow it to act for one minute. Add to the stain already on the film twice its volume of distilled water. Allow the diluted stain to act for three minutes. Wash in distilled water until pink. Blot and dry.

Leishman's stain

To prepare Leishman's stain dissolve 0·15 gram of the powdered stain in 100 c.c. of pure methyl alcohol. Solution has to be effected by grinding the powder in a mortar with successive small quantities of alcohol until it is all dissolved. The stain is improved by keeping for two or three weeks before use. Each batch of stain may vary a little with regard to optimum time of staining. The stain is used for the cytological examination of the blood, and for staining protozoa such as malaria parasites or trypanosomes.

Dry the film in the air. Do not fix by heat. Pour on a liberal quantity of the Leishman's stain and allow it to act for one minute. In hot weather the stain should be watched to see that it does not become thick or syrupy from evaporation of the alcohol. If this occurs, the stain will precipitate on the film. Precipitation may be avoided by adding more stain to that already on the slide. During this time the methyl alcohol in which the stain is dissolved brings about fixation. Using a Pasteur pipette with a rubber teat, add an equal quantity of distilled water to the stain already on the film. The water should be added carefully to avoid overflowing from the slide, and should be thoroughly mixed with the stain by sucking the mixture into and out of the pipette. A scum should form on the surface if the dilution has been properly carried out. Allow the diluted stain to act for at least four minutes. Ten minutes is an average time. Wash in distilled water. The film should be rose-pink in colour. If it is too purple, allow it to stand in distilled water until it is the correct colour. Pour off the water, blot and dry in the air. If the stain is left on the slide too long a precipitate may form. This may be washed off with a little undiluted Leishman stain or pure methyl alcohol. Such a washing should be followed at once by immersion in distilled water.

When examined under the microscope the preparation may appear to be too lightly stained. In this case the cedarwood oil is removed with xylol and the slide re-stained with equal quantities of the stain and distilled water. Films more than a week old do not stain well unless first washed in pure methyl alcohol. If a film is to be preserved, it is better to stain it and mount it in neutral Canada balsam rather than to leave it unstained.

9.–DIFFERENTIAL LEUCOCYTE COUNT

The stained blood film is examined with the $\frac{1}{12}''$ oil-immersion lens. The film is systematically traversed, preferably using a mechanical stage, and the numbers of each kind of cell seen are recorded up to a total of 400 cells. The quickest method of recording is to count the number of polymorphonuclears against the lymphocytes up to a total of twenty or thirty each, making a mark for each of the other forms of cell as they are met with. After reaching twenty or thirty for one of the more numerous cells, the figures are then recorded. In certain films it may be found that many of the cells, particularly polymorphonuclears, have become distributed along the edge. The edge of the film should, therefore, always be examined as well as the central portions. When an accurate differential count is required at least 400 unselected cells should be examined. Even with this number the maximum error due to chance is about 7·5 per cent of the total count. When there appears but little reason to attach importance to minor variations in the differential count it is sufficient to enumerate 200 cells.

Method of counting

Normal Differential Counts

(1) Adults:

	TOTAL PER C.MM.	PERCENTAGE OF TOTAL LEUCOCYTES
Neutrophil polymorphonuclears	3,000–6,000	60–70
Lymphocytes	1,500–2,700	25–30
Monocytes	350–800	5–10
Eosinophil polymorphonuclears	150–400	1–4
Basophil polymorphonuclears	0–100	0–1

(2) Infants and Children.—The important differences from adults concern the polymorphonuclears and lymphocytes.

	TOTAL PER C.MM.				PERCENTAGE OF TOTAL LEUCOCYTES			
	12 Days	1 Year	4 Years	8 Years	12 Days	1 Year	4 Years	8 Years
Neutrophil polymorphonuclears	3,500	4,500	4,000	3,500	25	35	40	55
Lymphocytes	9,500	6,500	4,000	2,000	55	50	40	30

10.–RETICULOCYTES

Supravital preparations

A film of 0·3 per cent solution of cresyl blue in absolute alcohol is made on one side of a specially cleaned No. 1 cover-slip. The film is made by allowing a drop of the cresyl blue solution to evaporate in the air.

The dye which is deposited is lightly polished on a piece of smooth paper. Prepared cover-slips should be marked with a grease pencil on the reverse side. They keep indefinitely. A very small drop of blood is placed on the charged surface of the cover-slip and another prepared cover-slip is dropped on top in a cornerwise manner. The blood therefore lies between the two cresyl blue layers. The blood rapidly spreads between the cover-slips by capillary action. After about a minute's contact the slips are carefully pulled apart with a sliding movement, the film is allowed to dry and is counterstained with Leishman's stain. For staining purposes the cover-slip may be conveniently held in a pair of cornet forceps. Some workers prefer to stain cover-slip preparations by inverting them in a watch-glass containing the stain. By this method precipitation of the stain may be avoided. After staining, the cover-slip is mounted on a slide with Canada balsam or cedarwood oil. The reticulocytes appear as cells containing a brilliant blue network or fragments of reticulum.

Value of Reticulocyte Count

Significance of high count

Reticulocytes in appreciable numbers indicate bone-marrow activity. Reticulocytes will therefore be increased beyond the normal 0·5 to 1 per cent of the average adult red count whenever increased bone-marrow activity is necessary. Moreover, the bone marrow may be overactive, but not healthily so; if, in such conditions, reticulocytes are found to increase following a particular line of treatment the amount of reticulocyte increase is not only a guide to progress, but also a measure of the efficacy of the treatment. A reticulocyte count is of value for the following purposes:

Significance of reticulocyte crisis

(1) Assessment of the efficacy of any given therapeutic measure.—If the treatment given in any particular anaemia produces an increase in reticulocytes, it can be assumed that the treatment will be at least partially effective. It should be realized that an increase in reticulocytes invariably precedes any increase in the total red count itself. Thus, in pernicious anaemia the first indication that liver treatment is going to be effective is an increase in the circulating reticulocytes. The increase occurs within a week of starting treatment and rises rapidly as the so-called 'reticulocyte crisis' until a little later the crisis is followed by a rise in the red-cell count itself. If a reticulocyte crisis occurs, it can be assumed that the treatment will be effective. When pernicious anaemia is treated with an adequate amount of a potent liver preparation the height of the reticulocyte 'crisis' is dependent on the initial red-cell count.

(2) Diagnosis.—In a very severe anaemia it is sometimes necessary to differentiate between pernicious anaemia and aplastic anaemia. The occurrence of a reticulocyte crisis with a potent liver preparation is diagnostic of pernicious anaemia, whereas the absence of the reticulocyte crisis, if not definitely proving aplastic anaemia, at least shows that some condition other than pernicious anaemia must be looked for. In acholuric ajundice (see Vol. I, p. 464) there is usually a persistent reticulocytosis,

Significance of persistent reticulocytosis

sometimes as high as 50 per cent; this often persists for months on end during the active phases of the disease. In no other condition, except sickle-cell anaemia, chronic malaria, chronic lead-poisoning and an acute and rare type of Hodgkin's disease, is there ever such a persistently high reticulocyte count. Marked reticulocytosis is said to be more constant in acholuric jaundice than increased fragility of the red cells.

(3) Determination of necessity for blood transfusion.—In a very anaemic person it is often necessary to consider whether blood transfusion should be performed. In such cases, if the reticulocyte count exceeds 5 per cent, it is rarely necessary to transfuse unless the red-cell count is one million or less. But even if the red-cell count is well above a million, and there is no reticulocyte response to intensive treatment, then the stimulating action of a small blood transfusion should not be neglected.

11.–STIPPLED-CELL COUNT

Enumeration of stippled cells is of value for estimating the course and prognosis in lead-poisoning. Some authorities have used the count as an alternative to the reticulocyte count, but the value of this practice is questionable. Stippled cells may be detected in a Leishman-stained film, and for an estimation of these cells it is preferable to leave rather more blue than usual in the film. The best method is to stain an ordinary blood film with methylene blue as follows:

Technique of staining

Methylene blue – – – –	1·5 gram
1 per cent potassium aluminium sulphate in 50 per cent methyl alcohol – –	0·5 c.c.
1 per cent sodium hydroxide in methyl alcohol – – – – –	0·2 c.c.
Methyl alcohol – – – –	100 c.c.

Immerse the film for four seconds and then wash rapidly in 0·025 per cent sodium bicarbonate solution in distilled water and dry between blotting paper.

12.–DETERMINATION OF CORPUSCULAR VOLUME

(*Alternative names.*—Total cell volume. Volume of packed red cells per 100 c.c. of blood)

Obtain exactly 10 c.c. of blood from a vein and place it in a 15 c.c. graduated centrifuge tube together with a quantity of a suitable anticoagulant. The tube is inverted to obtain thorough mixing and then centrifuged for about one hour at 2,500 revolutions a minute, the end result being read when the corpuscles attain a constant volume. The volume of packed red cells is read off directly from the tube and recorded as the number of c.c. of cells per 100 c.c. of blood. Variations in technique are mainly confined to the use of different anticoagulants, and attention must be paid to this point in order that the salt content may not cause shrinkage in the red-cell size.

Anti-coagulants

(1) Heparin and hirudin are the ideal anticoagulants, but expense prohibits their use in routine work. (2) Anticoagulants may be used in a solution isotonic with the plasma. Thus 3 per cent sodium citrate may be used in the proportion of 1 part to 9 parts of blood, or 1·6 per cent sodium oxalate, 1 part to 10 parts of blood. (3) Solid anticoagulants, which do not dilute the plasma but render it slightly hypertonic. When using these substances in the correct amounts the shrinkage caused by the change in the osmotic pressure is constant. The substances used are potassium oxalate, 20 mgm. per 10 c.c. of blood, or sodium oxalate 16 mgm. per 10 c.c. of blood. The substance is put into the tube by measuring exactly 1 c.c. of the 2 per cent solution of potassium oxalate or 1 c.c. of 1·6 per cent solution of sodium oxalate and evaporating to dryness in an oven. When the blood is added to the tube it must be well mixed to effect quick solution of the salt. When using solid potassium oxalate in the proportion of 20 mgm. per 10 c.c. of blood, the volume of packed red cells should be multiplied by 1·09 in order to correct for shrinkage. With Wintrobe's (1933) haematocrit, half-quantities of the substances are used as the examination is carried out on 5 c.c. of blood.

Normals

The normal figures for corpuscular volume per 100 c.c. of blood are 45 c.c. for men and 41 c.c. for women. For calculating the volume index (p. 473) 42 c.c. is taken as the normal 100 per cent. The corpuscular volume is altered by changes in the red-cell count and red-cell size.

By means of a haemoglobin determination, a red-cell count and a corpuscular volume reading, there can be calculated the colour, saturation and volume indices (pp. 472–4) as well as the absolute figure for mean corpuscular volume, mean corpuscular haemoglobin, and mean corpuscular haemoglobin concentration.

13.–RELATIONS BETWEEN RED-CELL COUNT, HAEMOGLOBIN CONTENT AND RED-CELL SIZE

Colour index

The colour index expresses the mean corpuscular haemoglobin content of the corpuscles and is arrived at by dividing the percentage of haemoglobin by the percentage of red cells. The colour index is the $\frac{\text{Percentage of haemoglobin}}{\text{Percentage of red cells}}$. In normal cases this is $\frac{\text{100 per cent}}{\text{100 per cent}}$, i.e. 1; but figures from 0·9 to 1·1 are not abnormal.

For the purposes of this calculation 5,000,000 red cells per c.mm. is considered to represent 100 per cent of red cells; this, partly because of long custom and partly because of convenience. Thus the percentage of red cells is automatically given by multiplying the first two figures of the red-cell count by 2. For practical purposes the observed haemoglobin percentage on the Haldane scale is directly available for the calculation of the colour index because the expression of the full normal average (i.e. 105 per cent), in terms of 100 per cent, makes less than 0·1 difference in the colour index. But the reading on the Sahli scale must be adjusted so that 85 per cent (Sahli) equals 100 per cent for colour index purposes; without this adjustment the colour index value is not true to ±0·1. The colour index may be calculated from the absolute value of haemoglobin in grams per cent by assuming that 14·5 grams haemoglobin equals 100 per cent.

Examples: (i) Haemoglobin = 40 per cent (Haldane)
Red cells = 4,000,000 per c.mm.
Colour index $\frac{40}{80}=0\cdot5$
(ii) Haemoglobin = 40 per cent (Sahli)
Red cells = 4,000,000 per c.mm.
Colour index $\dfrac{\frac{100}{85}\times 40}{80}=0\cdot6$
(iii) Haemoglobin = 12 grams per cent
Red cells = 4,000,000 per c.mm.
Colour index $\dfrac{\frac{12}{14\cdot5}\times 100}{80}=1\cdot0$

Volume index

The volume index expresses the mean volume of a single red cell compared with the volume of a normal cell. It is one way of expressing cell size. It is arrived at by dividing the percentage of corpuscular volume (p. 471) (calculating 42 c.c. as a 100 per cent) by the percentage of red cells.

Example: Red cells = 4,000,000 per c.mm.
Corpuscular volume = 40 c.c.
Volume index $\dfrac{\frac{40}{42}\times 100}{80}=1\cdot2$

Volume-thickness index

The normal volume index is 1, but figures from 0·95 to 1·05 are not abnormal. Given the volume index and the mean red-cell diameter there can be calculated a value known as the volume-thickness index (Haden, 1935). This index is important for the diagnosis of acholuric jaundice in which disease the cells are usually thicker than normal.

Saturation index

The saturation index represents the mean corpuscular haemoglobin concentration relative to normal, and therefore indicates the relation between haemoglobin concentration and red-cell size. The saturation index is obtained by dividing the colour index by the volume index. The normal saturation index is 1, the limits of normal variation being from 0·9 to 1·1.

Absolute determinations

By means of the red-cell count, the haemoglobin expressed in grams per cent and an accurate corpuscular volume, certain mean figures can be calculated without making reference to the fixed standard normals demanded by the index calculations. These absolute determinations are used by some instead of the indices.

The values are known as the (1) mean corpuscular volume, (2) mean corpuscular haemoglobin, and the (3) mean corpuscular haemoglobin concentration.

Mean corpuscular volume

Mean corpuscular volume is the mean or average volume of a single red cell. The result is expressed in cubic microns (c.μ) and is obtained by the following method:

$$\frac{\text{Volume of packed red cells in c.c. per 1,000 c.c. of blood}}{\text{Red cells in millions per c.mm.}}$$

Example: Corpuscular volume =40 c.c.
Red-cell count =4,500,000 per c.mm.
Mean corpuscular volume $=\frac{400}{4 \cdot 5}=88 \cdot 8$ cubic microns (c.μ).

The volume index may be obtained by dividing the mean corpuscular volume by the *normal* mean corpuscular volume.

Normals.—Average 87 c.μ, minimum 80, maximum 94.

Mean corpuscular haemoglobin

Mean corpuscular haemoglobin is the average haemoglobin content of a single red cell expressed in millimicrograms. It is obtained by the following method:

$$\frac{\text{Haemoglobin in grams per 1,000 c.c. of blood}}{\text{Red cells in millions per c.mm.}}$$

Example: Haemoglobin =12 grams per cent.
Red-cell count =4,500,000 per c.mm.
$\frac{120}{4 \cdot 5}=26 \cdot 6$ millimicrograms

The colour index may be obtained by dividing the mean corpuscular haemoglobin by the *normal* mean corpuscular haemoglobin.

Normals.—Average 29·5 (millimicrograms), minimum 27, maximum 32.

Mean corpuscular haemoglobin concentration

Mean corpuscular haemoglobin concentration is the mean or average haemoglobin concentration expressed as a percentage of a unit volume of cells:

$$\frac{\text{Haemoglobin in grams per 100 c.c. of blood}}{\text{Volume of packed cells in c.c. per 100 c.c. of blood}} \times 100$$

Example: Haemoglobin =12 grams per cent
Corpuscular volume =40 c.c.
Mean corpuscular haemoglobin concentration $=\frac{12 \times 100}{40}=30$ per cent

The saturation index may be obtained by dividing the mean corpuscular haemoglobin concentration by the *normal* mean corpuscular haemoglobin concentration.

Normals.—Average 35 per cent, minimum 33 per cent, maximum 38 per cent.

14.—VALUE AND SIGNIFICANCE OF THE INDICES AND ABSOLUTE DETERMINATIONS

Colour index

The colour index is widely used in clinical medicine. It indicates the average haemoglobin content of a corpuscle and is influenced partly by cell size and partly by haemoglobin saturation. If the cells are larger than normal and saturation is complete the colour index is high; when the cell size is normal and saturation is complete the colour index is not less than 0·9; when cell size is normal or smaller than normal and saturation is incomplete, the colour index is low. In general, a low index usually means small or unsaturated red cells whilst a high index means large saturated cells. The index therefore gives a rough estimate of microcytosis or megalocytosis as well as some idea of the iron content of the red cells. Quite obviously various combinations of cell size and saturation may occur which may produce a colour index that may be wrongly interpreted. Thus, if the red cells are large and the saturation low, the colour index may be low. Unless therefore a stained film has been examined or the volume index determined, the important phenomenon of megalocytosis may not be revealed by the colour index alone.

Volume index

Cell volume is a cubic measurement and is, therefore, a more sensitive indicator of cell size than mere linear measurement of cell diameter. A high volume index is always found in megalocytic anaemias, i.e. those anaemias in which liver therapy is required. A low volume index is found in all microcytic anaemias with the exception of acholuric jaundice, in which the cells, although small in diameter, are more nearly spherical than normal and therefore have a relatively large volume. The volume index is used for calculating the volume-thickness index which is increased when the cells are more nearly spherical than normal. The volume index is an easier method of estimating cell size than the laborious process of actual cell measurement.

Saturation index

The saturation index indicates the haemoglobin concentration in the corpuscle. When the index is low the cells are deficient in iron and iron treatment is required. When the index is normal the red cells are fully saturated and iron therapy is not required. The saturation index is of value for differentiating anaemias with a low colour index and for indicating which megalocytic anaemias require iron.

Absolute determinations

The mean corpuscular haemoglobin corresponds with the colour index, the mean corpuscular volume with the volume index and the mean corpuscular haemoglobin concentration with the saturation index. The interpretation of alterations in these absolute numbers is the same as for the corresponding indices.

15.–OBSERVATIONS ON THE RED CELLS IN A STAINED BLOOD FILM

(See Plate V, Nos. 1, 2, 10, 11, 12 and 18–26)

Alterations in the size, shape, and staining of the red cells as well as the presence of immature or nucleated red cells are observed in the stained blood film when making a differential leucocyte count. Changes in the red cells are of first importance for estimating the type of haemopoietic disorder—whether megalocytic or hypochromic or microcytic—and therefore whether due to a deficiency of the liver principle or of iron or to toxicity. The same facts should enable an estimate to be made of the compensatory marrow reaction, if any—a point of prognostic significance—and should suggest the possible primary cause of the anaemia.

Nucleated red cells

Any of the nucleated red cells found in the bone marrow may appear in the circulation. Megaloblasts, erythroblasts, and normoblasts are found when the bone marrow is excessively active and is regenerating blood in a relatively normal manner. Megaloblasts and early erythroblasts, both containing haemoglobin, indicate an alteration in the character of blood regeneration, in that erythropoiesis is shifted back towards an embryonic level. The following are the appearances of the various nucleated red cells:

CELL	APPROXIMATE SIZE	CYTOPLASM	NUCLEUS	REMARKS
Adult megaloblast	10–12μ	Deeply basophilic	Large. Occupies most of the cell. Stains lightly. Delicate threads of chromatin often with nucleoli	Cell outline often irregular. Very few present in normal marrow
Erythroblast	8–10μ	Early forms: basophilic. Late forms: polychromatic	Smaller than that of megaloblast. Chromatin less reticulate and more deeply stained. May be cartwheel	
Normoblast	6–8μ	Polychromatic or eosinophilic (orthochromatic)	Dense chromatin deeply stained. Sometimes eccentric	Nucleus may be lobed or cloverleaf
Embryonic haemoglobinized megaloblast (Ehrlich)	10–14μ	Polychromatic or eosinophilic	Large, clear and reticular but often much more mature	Large cells are known as gigantoblasts. Very mature forms may have pyknotic nuclei

Nuclear Remnants

Cabot rings

The two common features are the Cabot ring and the Howell-Jolly body. The Cabot ring is usually a single structure and is believed to be the remains of the nuclear membrane. It stains a reddish-purple with Romanowsky stains and appears either round or like a figure of eight. Cells with a Cabot ring commonly show evidence of immaturity and contain polychromatic or stippled material in ordinary films, or reticulum in a supravital preparation. Cabot's rings are found in pernicious anaemia, lead-poisoning, and leukaemias, but they have no diagnostic significance.

Howell-Jolly bodies

Howell-Jolly bodies are true nuclear fragments formed by karyorrhexis of the nucleus of the normoblast. One or two may be present in a single cell; they stain a reddish-blue colour. They are usually associated with other evidences of immaturity and are found in severe secondary anaemias, pernicious anaemia, leukaemia, and acholuric jaundice; they are particularly numerous after splenectomy.

Abnormalities in staining

The staining of red corpuscles varies according to whether they are mature or immature and whether they are stained supravitally (p. 469) or after fixation. A mature red cell shows no intracorpuscular structures when stained by supravital methods, and when stained after fixation is an homogeneous eosin colour. In a properly stained film the intensity of the eosinophil staining of the erythrocytes is a rough indication of the haemoglobin content of the cell. Normal cells stain a uniformly bright eosinophil colour. Cells with a poor content of haemoglobin stain less intensely, may have a centrally placed portion which is unstained, or, in extreme cases, may consist simply of a small circular ring of eosinophil cytoplasm at the periphery of the cell with the centre quite unstained. Such poorly staining cells are described as hypochromic and indicate iron deficiency.

Polychromasia and stippling

Two other abnormalities in staining may be evident in a stained blood film. The one, a diffuse purple or purplish-red staining of the whole cell, known as polychromasia or polychromatophilia; the other, the appearance in the cell of discrete dots of blue-staining material, the dots sometimes being fine and numerous, sometimes large and scanty. This latter phenomenon is known as basophil punctation or stippling. Marked stippling is common in lead-poisoning.

Both polychromasia and stippling are signs of immaturity, and the appearance, as found in an ordinary film stained by Romanowsky methods, is brought about by the large amount of reticular material present in the cell. The cells are in fact reticulocytes. In cases of infection with the parasite of benign tertian malaria, structures known as Schüffner's dots may be found in the red cells. They appear as fine reddish granules in Romanowsky stained films. They are not identical with, or in any way related to stipples, and are almost certainly a degenerative phenomenon. Schüffner's dots are regarded as a diagnostic sign of benign tertian malaria.

Reticulocytes

Reticulocytes are normally present in the circulation to an extent of less than one per cent of the red cells. In anaemic states, and particularly when much red-cell regeneration is occurring, the percentage may be more than 50. Reticulocytes are young red cells. They can only be demonstrated satisfactorily by supravital staining, either in a wet preparation, or in a sample of blood stained supravitally and then counterstained with a Romanowsky stain (p. 469). In preparations made in the

NORMAL CELLS OF THE PERIPHERAL BLOOD

1. Erythrocyte. Size 7 to 7·5μ.
2. Reticulocyte (stained supravitally and counterstained with Leishman's stain). Normally less than 1 per cent of total red cells. Numerous in normal marrow.
3. Neutrophil polymorphonuclear } granulocytes. Size 10 to 12μ.
4. Eosinophil polymorphonuclear } granulocytes. Size 10 to 12μ.
5. Basophil polymorphonuclear } granulocytes. Size 10 to 12μ.
6. Large lymphocyte. Predominant cell in infancy. Size 12 to 15μ.
7. Small lymphocyte. Size 6 to 7μ.
8. Thrombocytes or blood platelets. Size 2 to 4μ.
9. Monocyte. Size 16 to 20μ.

NORMAL CELLS OF THE MARROW AND LYMPHATIC CENTRES OF HAEMOPOIESIS

(Found in the peripheral blood in disorders and diseases of the blood)

10. Megaloblast. Size 10 to 12μ—note lack of haemoglobin.
11. Erythroblast. Size 8 to 10μ—note lack of haemoglobin.
12. Normoblast. Size 7 to 8μ—contains varying amounts of haemoglobin.
13. Myeloblast. Size 11 to 18μ—parent cell of the granular series. Characteristic of myeloblastic leukaemia when found in the circulation.
14. Premyelocyte—transitional between myeloblast and myelocyte. Numerous in the blood in myeloid leukaemia.
15. Neutrophil myelocyte—the differentiated precursor of the neutrophil polymorphonuclear. Eosinophil and basophil myelocytes are also found.
16. Metamyelocyte—the youngest mature neutrophil polymorphonuclear.
17. Lymphoblast. Size 15 to 20μ—numerous in the blood in acute lymphatic leukaemia.

ABNORMAL RED CELLS

(Found in the circulation)

18. Haemoglobinized megaloblast (megaloblast of Ehrlich). Size 10 to 14μ. Characteristic of the late stages of pernicious anaemia. Found also in leukaemia.
19. Haemoglobinized erythroblast.
20. Poikilocyte—probably a fragmented red cell. Found in most severe anaemias.
21. Macrocyte (megalocyte). Size 8 to 13μ. Characteristic of pernicious and other macrocytic anaemias.
22. Microcyte. Size 4 to 6·5μ. Found in iron-deficient and toxic anaemias. Often deficient in haemoglobin.
23. Punctate basophilia or stippling—common in lead-poisoning.
24. Polychromasia—an immature red cell found in various anaemias. By supravital methods the cell contains much reticular material; the cell is a reticulocyte.
25. Howell-Jolly bodies—nuclear fragments.
26. Cabot ring—the remains of the nuclear membrane.

Stained with Leishman's stain. × 1,000.

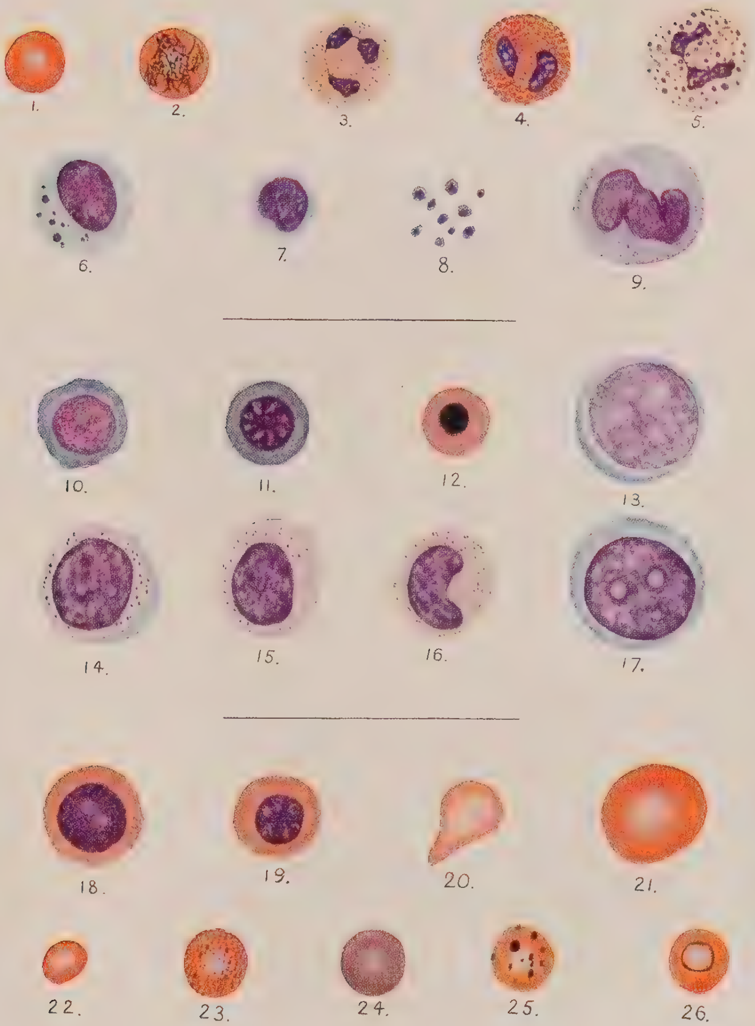


PLATE V

[*To face p.* 478

last-named manner the reticulocyte contains a network of blue-staining material either in the form of fibrils or granules.

Abnormalities in size

The mean diameter of the normal erythrocyte is approximately 7·25μ. In anaemic conditions many cells may be larger than normal—from 8μ to as much as 13μ; such cells are known as megalocytes or macrocytes. In other conditions some red cells may be smaller than normal—from 4 to 6·5μ diameter—and these are known as microcytes. When there is great variation in the size of the cells the phenomenon is known as anisocytosis. The experienced microscopist, well used to the magnification of his own microscope, can readily observe gross or moderate changes in cell size. The indices, particularly the volume index, less certainly the colour index, afford reliable evidence of alterations in cell size. Size can also be determined by direct measurement according to the technique of Price-Jones or by one of the diffraction methods of which Eve's halometer is fairly accurate in experienced hands. Anisocytosis indicates a disordered erythropoiesis and is occasionally a more marked feature of pernicious anaemia than the more characteristic megalocytosis; it is found, however, in microcytic as well as megalocytic anaemias.

Anisocytosis

Abnormalities in shape

Poikilocytes

Normal red cells are circular biconcave discs. Irregularly shaped erythrocytes are found in anaemic states, and particularly when there is much anisocytosis. The most characteristic are pear-shaped and are known as poikilocytes. It is probable that the smaller poikilocytes are really fragments of red cells. Megalocytes are often oval, whilst microcytes may have a very irregular outline. Apart from pathological conditions, two hereditary anomalies of shape may be found, namely, the sickle-shaped cells of sickle-cell anaemia and the oval or elliptical cells of ovalocytosis. Sickle cells are easily identified only in wet films; they are especially evident after the preparation, ringed with soft paraffin, has been allowed to stand from six to twenty-four hours (see Vol. I, p. 459)

16.–OBSERVATIONS ON THE LEUCOCYTES IN A STAINED BLOOD FILM

(See Plate V, Nos. 3–7, 9, and 13–17)

Mature cells

An infection which is well resisted is characterized by the appearance in the blood-stream of active young polymorphonuclear cells. The number and proportion of the young cells depend upon the nature of the stimulus and upon the reaction of the person. For this reason an estimate of the increase in young cells under conditions of infection helps in diagnosis and prognosis. The age of a polymorphonuclear cell may be gauged by the lobulation of the nucleus. Old cells have multilobular nuclei, the youngest have a nucleus shaped like the letter C with slight lobulation. Cooke classified the cells into five groups. In Group 1 the nucleus is either unlobed or if there are lobes, then these are joined by a thick band of chromatin; if the band of chromatin is a thin filament the cell belongs to Group 2. In Group 2 there are two

Types of polymorphs

lobes joined by a thin filament, in Group 3, three lobes and two filaments, in Group 4, three filaments, and in Group 5, four or more filaments. When making a differential count the cells are placed in their various groups and the percentage of each determined. The normal proportions are Group 1, 10 per cent; Group 2, 25 per cent; Group 3, 47 per cent; Group 4, 16 per cent; Group 5, 2 per cent. With infection, there is always a 'shift to the left', that is, an increase in the percentage of bilobed and monolobed cells irrespective of leucocytosis or leucopenia. A series of counts at intervals showing an increasing shift to the left are highly suggestive of an infective process. The examination is of value in obscure abdominal conditions.

Immature cells

Whenever the leucoblastic tissue of the marrow is extremely active, myelocytes and even myeloblasts may be found in the peripheral blood.

Myelocytes

A few myelocytes are often found in the blood of children but in adults this finding is rare apart from frank leukaemia, aleukaemic leukaemia, severe infections associated with a large leucocytosis and in association with carcinomatous deposits or other malignant tumours of the bone marrow. Lymphoblasts are characteristic of lymphatic leukaemia in its acute form but may also be found in the diseases associated with lymphocytosis, particularly whooping-cough and glandular fever.

Myeloblasts

Myeloblasts may be differentiated from lymphoblasts partly by fine differences in nuclear structure and partly by peroxidase staining. Identification is assisted by the occasional presence of all grades of development between the primitive cell and readily recognized more mature cells.

Stain for peroxidase

Peroxidase staining is best carried out by Beacon's method. A simpler technique is as follows: fix the films for two minutes with a freshly prepared mixture of 1 part of formaldehyde solution (40 per cent) and 9 parts of 95 per cent alcohol. The preparation is then washed in tap water and stained in a freshly prepared benzidine solution made by dissolving a few grains of benzidine in 10 c.c. of 40 per cent alcohol, adding one drop of fresh hydrogen peroxide. After five to ten minutes the films are washed in tap water and counterstained with 1 per cent methylene blue for a few seconds. The cytoplasm of the lymphocytes is stained blue, red cells appear green, and cells of the granular series appear amber. Prussian blue oxidase granules are found in granulocytes, myelocytes and myeloblasts, provided the latter are not too primitive; monocytes and premonocytes are usually faintly oxidase positive.

II.—COAGULATION

(BLOOD PLATELETS)

(See Plate V, No. 8)

164.] The blood platelets vary from 200,000 to 500,000 per c.mm. during health and are liable to fairly rapid changes in number within this range from day to day or from one part of a day to another.

Platelet count

The following is a satisfactory technique for a platelet count.

A syringe of 1 c.c. capacity and preferably of the tuberculin type is mounted with a needle of fairly wide bore. The syringe and needle are sterilized by rapidly drawing in and out a quantity of liquid paraffin heated well above the boiling point of water. Into this syringe is drawn 0·2 c.c. of 3·8 per cent sterilized solution of sodium citrate, and 0·8 c.c. of blood from a vein is drawn into the citrate fairly rapidly. The needle is removed and the sample immediately transferred to a glass tube lined with paraffin wax. Platelet counts are inaccurate if the blood comes in contact with a water-wettable surface. The most practical way of avoiding this difficulty is to use a well-oiled syringe and glass-ware lined with paraffin wax. With the above manipulations the blood is always in contact with a waxed surface and in the presence of an anticoagulating substance. For counting the platelets the blood must be diluted about twenty times with the following solution:

Diluting fluid

Sodium citrate – – – –	0·2 gram
Sodium chloride – – –	0·8 gram
1 per cent brilliant cresyl blue in water –	1 c.c.
Formalin – – – –	2 c.c.
Distilled water – – – –	to 100 c.c.

The dilution of the blood with this solution is carried out with a teated glass pipette which has been lined with paraffin wax. Dilution is accomplished by means of drops either on to a paraffined slide or into a paraffined tube. A small drop of the mixture is placed on a clean microscope slide which is then inverted over a clean No. 1 cover-slip. The preparation is immediately sealed with melted paraffin-vaseline mixture. The platelets are counted with the $\frac{1}{12}''$ oil-immersion lens and an eyepiece which preferably contains a squared diaphragm. Successive fields are examined until about fifty platelets and the accompanying red cells have been counted. If the platelets are scanty about 2,000 red cells should be enumerated. The dilution given above is such that the average microscope field contains fifty to sixty red cells. In patients with high red-cell counts a dilution of 1 in 30 or 1 in 40 may be required. The normal ratio of platelets to red cells is about one to sixteen. The absolute number of platelets is obtained by dividing the ratio found into the number of red corpuscles per c.mm. as determined by an accurate red-cell count. The platelets are recognized as small oval or star-shaped discs with a finely blue-staining granular centre; they show Brownian movement. In order to preserve the uniform distribution of red corpuscles and platelets it is essential to carry out the manipulation rapidly. The presence of clumps of platelets invalidates the count.

Alternative method

When blood cannot be obtained from a vein the following method is fairly accurate. Balance a fair-sized drop of sodium citrate solution on the ball of the patient's finger. Prick through the centre of the drop and allow the blood to mix on the finger. Remove the drop of citrated blood with a paraffined pipette and carry out the count in the manner outlined above. Counts obtained by this method tend to be somewhat low.

Significance of the platelet count

Blood platelets play a part in bringing about the coagulation of shed blood and the arrest of haemorrhage. Purpura and bleeding from mucous membranes (epistaxis or menorrhagia) occur when the platelet count is markedly reduced—a figure of 40,000 per c.mm. is regarded as the critical level. Except in the disease essential thrombocytopenia, some other factor causing capillary damage always contributes to, or is the sole cause of, purpura. Many authorities believe that damage to the capillary endothelium is also a factor in essential thrombocytopenia. The platelets are reduced in essential thrombocytopenia, in diseases which injure the bone marrow, such as acute infections (haemorrhagic exanthemata), in benzene, X-ray or radium poisoning, in leukaemia, and in metastatic neoplasms in the marrow.

An increase in platelets is sometimes seen as a result of thrombosis. Platelets are increased after splenectomy and to a less extent after any surgical operation or any severe injury such as a fractured femur. During recovery from a severe haemorrhage or illness, after parturition and often after an acute fever, the platelet count may be high.

Coagulation time

Prolongation of coagulation time occurs whenever there is interference with the conversion of fibrinogen into fibrin. The time is markedly prolonged in haemophilia in which the blood platelets are believed to be unduly stable so that they do not disintegrate and liberate thrombokinase. In obstructive jaundice, in chloroform and phosphorus poisoning the coagulation time may be prolonged owing to a disturbance of the fibrinogen-forming function of the liver. The coagulation time is not prolonged in essential thrombocytopenia because the platelets, although few in number, liberate sufficient thrombokinase for clot formation to occur. The coagulation time is shortened in typhoid fever, after haemorrhage, in endocarditis and after splenectomy. Suggested theories include an increased fragility of the blood platelets and a deficiency of antithrombin.

The following methods are used for determining coagulation time:

Determination of coagulation time

(1) *Capillary tube method of Wright* (1921): The finger is pricked, the time at which the prick was made being noted. When there is a free flow of blood, a small column of blood is allowed to run by capillary attraction into a series of capillary tubes of equal calibre. About a dozen tubes are sufficient. The tubes are sealed with plasticine and then immersed in a water-bath at 37° C. After waiting for four minutes the column of blood in one of the tubes is discharged into a porcelain dish containing water at 37° C. Thereafter at intervals of thirty seconds further columns of blood are expelled. When the blood has the form of a worm-like clot the end-point is reached and the time noted. A similar examination should be made with normal blood and the result expressed as a percentage of the normal clotting time. The clotting time by this method is usually from six to ten minutes if performed at 37° C. If the examination is performed at room temperature, the clotting time is from ten to

fifteen minutes. In these circumstances the first column should not be expelled until the expiration of about nine minutes.

(2) *Method of Lee and White* (1913): 1 c.c. of blood is collected from a vein in the arm in a perfectly dry syringe and placed in a clean test-tube, 8 mm. in diameter. A rubber cork is inserted and at every half-minute the tube is inverted until the blood has formed a firm clot. The time is then noted. The normal time by this method is from four to seven minutes. A control with the normal blood should always be performed. The method avoids the mixing of tissue juices with the sample of blood; for this reason the end-point is relatively constant.

Bleeding time

The bleeding time is prolonged in diseases in which the platelets are greatly reduced. By bleeding time is meant the time taken for the bleeding from a single needle puncture to stop. This type of bleeding is stopped by intravascular thrombi composed of platelets; these adhere to the injured point in the vessel. The thrombus is therefore in this case formed from flowing blood rather than stationary blood.

The bleeding time is prolonged in essential thrombocytopenia. In haemophilia the bleeding time is normal because the platelets, although unable to disintegrate, still retain the power of adhering to injured capillary endothelium. For the test, a single puncture is made in the lobe of the ear. A piece of blotting paper is applied to the drop of blood every thirty seconds without touching the skin and the applications are repeated until the bleeding stops. The normal time is from two to five minutes.

Features of the blood clot

When normal clotted blood is allowed to stand, the clot contracts and expresses serum. This contraction should begin within a few hours and be complete in twenty-four hours. For proper contraction considerable numbers of platelets are required. If platelets are deficient, as in essential thrombocytopenia, the clot is soft, friable and does not retract. The clot in haemophilia has the same characters.

The following table summarizes the facts about coagulation factors in some of the purpuric and haemorrhagic diseases.

	PLATELET COUNT	BLEEDING TIME	COAGULATION TIME	BLOOD FIBRINOGEN
Essential thrombocytopenia	Reduced	Prolonged	Normal	Normal
Anaphylactic purpura	Normal	Normal	Normal	Normal
Haemophilia	Normal	Normal	Very prolonged	Normal
Hereditary haemorrhagic thrombasthenia	Normal	Prolonged	Normal	Normal
Constitutional thrombopathy	Normal	Prolonged	Normal	Unknown
Pseudo-haemophilia hepatica	Normal	Normal	Prolonged	Reduced

III.—CULTURE

Apparatus

165.] Apparatus required for blood culture is as follows:

(a) A 10 c.c. or 20 c.c. syringe, sterilized by boiling in water. The syringe should not come into contact with an antiseptic, and when it is removed from the sterilizer the parts should be fitted together with the aid of forceps so that neither the needle, nozzle nor syringe is touched by the fingers. Sharp needles are essential, and the best practice is to keep them in sterile olive oil until required for use. The syringe and needle may be assembled in the laboratory and placed inside a metal carrier, which has itself been boiled. Failing a metal carrier, a large-sized test-tube with a piece of sterile wool at the bottom may be used.

(b) 100 c.c. of sterile glucose broth in a stoppered flask. One flask is the minimum. Ideally at least three flasks should be used; these can be incubated under different conditions. Duplicate cultures, using large and small quantities of blood, are also a help in assessing the significance of possible contaminants such as staphylococci.

(c) Sterile swabs; supply of antiseptic such as alcohol or solution of iodine; tourniquet or bandage.

Method

All windows and doors must be closed to exclude draughts. The skin of the patient's arm at the bend of the elbow is thoroughly sterilized by a plentiful application of antiseptic. This is essential in order to avoid contaminating the culture with skin organisms such as staphylococci. A tourniquet is applied above the bend of the elbow and the veins in the antecubital region are rendered turgescent by making the patient alternately open and clench the hand. The needle is inserted into a prominent vein, and 10 to 20 c.c. of blood are withdrawn into the syringe. In order to avoid contamination it is almost essential to get into the vein at the first prick of the needle. The tourniquet is then released, the needle withdrawn from the vein and detached from the syringe by means of forceps. The blood is distributed in amounts of 5 to 10 c.c. into the culture flasks as follows: A flask of broth is unstoppered, the stopper being held in the hand sheltering the open flask as much as possible, the blood is added to the broth, and the flask immediately re-stoppered. The broth and blood are thoroughly mixed by rotation of the flask. The syringe and needle should be washed out with water. The puncture wound should be dressed with gauze or cotton-wool. When the flasks have to be transported some distance it is advisable to substitute a sterilized rubber stopper for the cotton-wool plug. Glass-stoppered bottles are also convenient for transportation. Flasks should be incubated at 37° C. On the following day a smear preparation of the culture is examined for organisms, and at the same time a subculture is made on to a slope of a solid medium. If the examination is negative, a smear and a subculture should be made daily for fourteen days or even longer before assuming that the specimen of blood is sterile.

Successful blood cultures depend upon the avoidance of contamination and of clotting of the blood and upon an adequate dilution of the blood with a large quantity of broth. The most common contaminants are *Staphylococcus albus* from the skin, and aerial bacteria which are carried into the culture by draughts. Clotting can be avoided by a proper mixture of the blood and broth, or by the incorporation in the medium of a small quantity of trypsin. It is essential that the culture should be made at the bedside. Shed blood has very strong bactericidal properties, particularly if it is allowed to clot, and the few organisms which may be contained in a sample of 5 or 10 c.c. are rapidly killed unless the bactericidal substances are promptly diluted with a large supply of broth. Samples of blood submitted in sterile test-tubes, whether the blood is clotted or not, are entirely unsuitable for culture.

In infants, the only feasible site for obtaining blood is the longitudinal sinus. The procedure is rarely justified.

Blood culture is successfully employed in the early diagnosis of typhoid and paratyphoid fevers, in undulant and abortus fevers, infective endocarditis and in septicaemia.

Interpretation

With a pyrexia of unknown origin, cultural conditions should be arranged to ensure a growth of any likely organism. Aerobic cultures will grow pyogenic cocci, *Brucella melitensis* and organisms of the typhoid group, but certain streptococci as well as sporing anaerobes can only be cultivated under anaerobic conditions, and *Brucella abortus* requires an atmosphere containing 10 per cent of carbon dioxide for successful primary culture. Typhoid and paratyphoid infections as well as frank septicaemias should yield a positive result in 48 to 72 hours. Some of the more chronic streptococcal infections, particularly subacute bacterial endocarditis, may require incubation for 7 to 14 days. *Brucella* cultivations are notoriously slow to appear; the culture should not be discarded as negative for at least 21 days. Typhoidal infections yield positive blood cultures in 90 per cent of cases during the first 10 days of the disease; after this time the disease usually ceases to be a bacteriaemia and negative results are obtained.

A positive blood culture has not always a grave significance. The early phases of pneumococcal pneumonia are almost always associated with bacteriaemia; this does not affect the prognosis unless it is persistent. After dental extractions a positive blood culture can usually be obtained within a short time of the operation; the finding has no significance unless it persists for more than a few hours.

With staphylococcal infections, significance is usually attached to *S. aureus* but not to *S. albus*. But if the test is performed by a skilled pathologist and a positive result is obtained in duplicate cultures and in repeated cultures, a *S. albus* infection cannot be disregarded. Chronic streptococcal septicaemia or endocarditis is not excluded by a single negative blood culture. Repeated cultures should be made at intervals when clinical signs are suggestive. Puerperal infections are sometimes due to an anaerobic streptococcus. It is said that a higher percentage of positive results is obtained if a culture is made while the temperature is rising.

IV.—SEROLOGICAL TESTS

Collection of blood

166.] Blood serum is required for the Wassermann test, the Widal reaction and other serological tests. It is convenient to obtain the blood in amounts of 4 to 5 c.c. by vein puncture as described for blood culture (p. 484). The specimen should be placed in a sterile tube and allowed to clot. On contraction of the clot the clear serum may be removed with a pipette. The separation of the serum may be hastened by centrifugalization. When venepuncture is impracticable the specimen can be obtained by puncturing the skin of the finger near the base of the nail with a straight Hagedorn needle; the blood is collected in a Wright's blood capsule (Fig. 74). The success of the method depends upon getting a continuous free flow of blood. If coagulation occurs before the capsule is three-quarters full, another capsule should be used. The needle and the patient's finger should be cleaned with alcohol, and a light tourniquet such as a rubber band applied to the base of the finger. When the finger is congested, puncture the skin near the nail bed by a deep thrust of the needle. As soon as a large drop of blood collects dip the bent limb of the capsule into it and allow the blood to pass in by capillary action. When the capsule is three-quarters full, heat the straight end in the flame and seal off the tip. When the glass is cool and the blood retracted from the bent limb, seal off the latter.

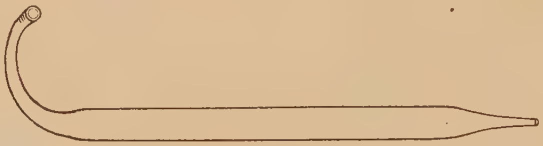


FIG. 74.—Wright's blood capsule
(From the Author's *Medical Bacteriology*)

Method for infants

The serum can be separated by the centrifuge, the bent limb serving to hang the capsule on the rim of a centrifuge bucket. The capsule is opened by filing and breaking off the bent end. The serum can be removed with a teated capillary pipette.

The capsule method is the only practicable one for obtaining amounts of 1 c.c. of blood from infants. In infants the big toe or heel is punctured in preference to the finger.

Haemolysed samples of blood are unsuitable for the Wassermann test. To avoid haemolysis use clean tubes and a syringe free from any traces of alcohol. Syringes kept in alcohol should be washed out with saline before use.

1.–AGGLUTINATION TESTS

Agglutination tests are of value for the diagnosis of typhoid fever, paratyphoid fevers, bacillary dysentery, cholera, undulant fever, glanders and typhus fever. Agglutinins are developed as a phenomenon of active immunity; they are not therefore found until the disease has existed for from 7 to 10 days and sometimes longer.

Methods

The test may be performed by a macroscopic or a microscopic method but the former is always preferable if sufficient serum is available. The principle of the test is to make a series of ascending doubling dilutions of the patient's serum, to mix with these a suspension of the organism to be tested, to incubate the mixture for the appropriate time and then examine for agglutination. The practice of the test depends on the method favoured by the worker for making the serum dilutions. Dilutions should range from 1 in 10 to 1 in 1,200 for a diagnostic test and a separate series is required for each organism to be tested. Dilutions may be made with a teated Pasteur pipette marked to deliver a constant volume or with accurately graduated glass pipettes.

For typhoid and paratyphoid in persons not previously inoculated, for dysentery, cholera, glanders, and the Weil-Felix reaction for typhus fever (suspension of *B. proteus* X 19) the tubes should be incubated in a water bath at 50° to 55° C. with the level of water half-way up the tubes. For typhoid and paratyphoid infections in persons previously inoculated and for brucella infections the tubes must be incubated further for 12 hours at 37° C. Information as to previous inoculation should always be given when a sample of blood is submitted for test.

Interpretation

In typhoidal fevers Grünbaum's reaction, more commonly known as Widal's reaction, tends to become positive after the tenth day of the disease and is maximal about the twenty-first day. The reaction may not be positive until quite late in the disease, and in some cases may not appear at all. Owing to the natural agglutinating power of some sera, the reaction is not diagnostic unless it occurs at a titre of at least 1 in 100. When agglutination at a lower titre is obtained the reaction should be repeated after two days, by which time it will, in a positive case, have risen to a diagnostic level.

The interpretation of the Widal reaction, which is comparatively simple in an uninoculated person, has nowadays been complicated by the fact that many persons have received antityphoid inoculation. Such persons as the result of their inoculation, frequently agglutinate typhoid and paratyphoid bacilli in high titre; the titre depends on the time that has elapsed since the inoculation. Agglutinins of considerable strength may be present for from 6 months to 2 years; after this time the titre declines and the agglutinins may apparently disappear. Persons who have received antityphoid inoculation should be tested for agglutinating power every other day for three or four determinations. A rise in titre of any one of the typhoid or paratyphoid organisms suggests but does not prove an active infection with that organism. A rising titre is not absolutely diagnostic for the reason that inoculated persons have always a small residue of agglutinins however distant their inoculation may have been. These residual agglutinins, under the non-specific stimulus of *any* fever, may rarely be considerably enhanced and so give rise to an erroneous diagnosis. This non-specific stimulation of agglutinins is known as the anamnestic reaction.

H and O agglutinogens of typhoid

Research into the antigenic structure of the typhoidal organisms has shown that the flagellar part of the organism gives rise to one type of agglutinin, and the somatic or corporeal part to another. The flagellar, or H, agglutinogen is rapidly agglutinated into large flakes and the antigen is heat-labile, destroyed by alcohol but unaffected by formalin. The somatic, or O, agglutinogen is slowly agglutinated into small compact granules and the antigen is thermostable, destroyed by formalin but not by alcohol. Formalinized suspensions of a typhoid bacillus contain therefore nothing but H agglutinogen whilst alcoholic suspensions contain nothing but O agglutinogen. Prophylactic vaccines contain both H and O antigens, but it is only the H coarse-flaking agglutinin which is stimulated by the anamnestic reaction and which is detected by the routine Widal technique. The O agglutinin is not so stimulated, and an O titre of 1 in 100 is accepted as diagnostic unless the patient has been inoculated within the previous few months; a rising O titre is still more significant. The Widal reaction in an inoculated person should therefore be performed with both H and O suspensions.

In order that Widal's test may be completely comprehensive and include even the rarer causal organisms of typhoidal fevers in Western Europe, it must, in difficult cases, include *B. paratyphosus* C (Hirschfeld's bacillus) and the European monophasic *B. suipestifer*. For a complete test there are required: H suspensions of *B. typhosus*, *B. paratyphosus* A, *B. paratyphosus* B and C in type phase and one in group phase; O suspensions of *B. typhosus*, *B. paratyphosus* A and B, and either *B. paratyphosus* C or *B. suipestifer*.

Undulant fever

In brucella infections the development of agglutinins is somewhat irregular. High titres are common with *Br. melitensis* infections and quite frequent in abortus fever. But many proven cases, especially of abortus fever, fail to develop agglutinins at all or only do so at low titres. No diagnostic titre can therefore be established and the failure to obtain a positive test does not exclude the disease. Low titres are significant when associated with clinical probability. In areas where undulant fever is endemic, as in Malta, many healthy subjects have low-titre agglutinins, probably as the result of an unnoticed sub-infection.

Bacillary dysentery

In bacillary dysentery agglutinins are developed only in low titre.

Typhus fever

In typhus fever (Weil-Felix reaction) the patient's serum agglutinates a suspension of *B. proteus* X 19 to a high titre. The organism does not cause the disease but has probably an antigenic structure similar to that of the *Rickettsia prowazeki*.

2.–COMPLEMENT-FIXATION TESTS

Complement-fixation tests are applied for the diagnosis of diseases in which the immune bodies are of the type known as amboceptor, e.g. bacteriolysins and haemolysins. The test is not often performed outside an equipped laboratory. The technique is complex and is only satisfactorily performed by skilled technicians. Furthermore, such tests are reliable only when they are performed in bulk as in a large institute; single tests are open to many fallacies. Complement-fixation tests are performed for syphilis, tuberculosis, gonorrhoea, hydatid disease, filariasis and a few other diseases.

Interpretation of Wassermann reaction

In syphilis the Wassermann reaction becomes positive about two weeks after the onset of the primary sore and becomes progressively more pronounced with the advance of the disease. In all cases of genital ulcer it is advisable to perform Wassermann reactions, month by month, until four months have elapsed. A negative reaction in the absence of treatment may then be taken to exclude the disease. In cerebrospinal syphilis, both the blood and cerebrospinal fluid should be tested, as sometimes only the spinal fluid is positive. In congenital syphilis the blood of the mother as well as of the child should be tested, particularly if there is any difficulty in obtaining a specimen from the child. In secondary syphilis the Wassermann reaction is always positive but in a small proportion of tertiary cases the reaction is negative despite convincing clinical signs.

A positive Wassermann reaction is given in cases of yaws and in many cases of leprosy as well as a few cases of tuberculosis. Some inhibition of haemolysis is occasionally found in malaria and acute haemolytic streptococcal infections. The Kahn flocculation test is slightly more sensitive than the Wassermann reaction in treated cases of syphilis.

Tuberculosis

In tuberculosis a complement-fixation test has a limited value. A negative reaction does not exclude the disease nor does a positive reaction indicate active infection. In general the interpretation of the result should be assessed with the clinical and other findings in the same manner as a tuberculin test. The reaction is usually negative in acute or moribund cases, and positive with chronic active disease. With cessation of activity the reaction may remain positive for a long time; it does not necessarily become negative as does the Wassermann reaction. A positive reaction is induced by tuberculin inoculation; such treatment therefore prohibits interpretation of the test. In short, a positive reaction means that infection with *B. tuberculosis* has occurred at some time and a strongly positive one suggests present activity. If a positive reaction becomes negative in parallel with a cessation of all signs of activity, this is additional evidence of quiescence.

Gonorrhoea

The same principles apply to gonorrhoea as to tuberculosis. The reaction is rarely positive when the disease is confined to the anterior urethra or the cervix uteri. With deep-seated lesions a positive reaction is usual. A positive reaction is of great value when investigating obscure cases of arthritis, fibrositis or iritis in that it indicates the nature of the disease sometimes long after the original infection has been forgotten. Vaccine therapy induces a positive reaction and prohibits proper interpretation. A positive reaction may persist long after cure of the disease, but a positive reaction which becomes negative is a valuable criterion of cure.

Hydatid disease

Positive reactions for hydatid disease are diagnostic but are not often strongly marked unless the cyst is leaking.

3.–FLOCCULATION AND PRECIPITIN TESTS

Syphilis

The Kahn test is the most widely practised of the many flocculation tests for syphilis. The test is eminently suitable for the tropics and for small institutions or private practice where an animal house is not maintained. If a single test is performed, it is essential to do simultaneous control tests with known positive and negative sera. Kahn's standard antigen is obtainable from the Difco laboratories, Michigan, who have agents in all parts of the world.

Technique

Heat the patient's serum to 56° C. for half an hour. Dispose into three tubes 0·15 c.c., 0·1 c.c. and 0·05 c.c. of the serum and add to the second and third tubes 0·05 and 0·1 c.c. respectively of 0·9 per cent saline in order to bring all the volumes to 0·15 c.c. Into a fourth tube place 0·15 c.c. of saline to act as control. In a separate tube dilute the antigen with 0·9 per cent saline according to the directions supplied with each batch of antigen. Allow to stand for ten minutes and then add 0·5 c.c. to each of the serum tubes and the control tube. Shake the mixture for three minutes and then add 1 c.c. of 0·9 per cent saline to each tube. Examine for flocculation.

For reliable results all glass-ware must be scrupulously clean and all reagents free from contamination and dirt.

The test is as reliable as the Wassermann test and in treated cases of syphilis is sometimes more sensitive. In doubtful cases of syphilis both tests should be performed. The Kahn test is not satisfactory for cerebrospinal fluid.

Hydatid disease

The blood serum of the patient with hydatid disease gives a precipitin reaction with an extract of an hydatid cyst in a considerable proportion of cases. As with complement fixation the reaction is strongly positive when the cyst is leaking.

Identification of blood stains

Dried blood (blood stains) contains an antigen which will give a precipitin reaction with an appropriate serum from the species of animal from which the blood is derived. The stained material should be submitted *in toto* to a laboratory.

4.–HAEMAGGLUTINATION

(BLOOD GROUPING)

The phenomenon of haemagglutination is of vital importance for determining the compatibility of donor and recipient when carrying out a blood transfusion; the gravest accidents may follow the transfusion of an incompatible blood. Being dependent on hereditary factors, the phenomenon has also a limited application for determining paternity as well as for other medico-legal purposes. This subject is dealt with in an article on BLOOD TRANSFUSION (p. 530).

V.—PHYSICAL AND CHEMICAL CHANGES

1.–SEDIMENTATION OF RED CELLS

Method for infants

167.] The rate of sedimentation of red cells in the blood plasma is a good index of the progress of an infective process, especially in rheumatoid arthritis and tuberculosis. The test is sensitive but is quite non-specific. It has proved of greater value for estimating the progress of an infective condition than for determining if such a condition is present. A series of tests at regular intervals is of more value than a single test; such a series provides a reliable record of progress.

The sedimentation test is easy to carry out. At the same time, the test is sensitive and a careful technique is essential, otherwise the results are valueless. The test may be performed either in wide-bore tubes or in narrow ones. In the former the rate of sedimentation is much more rapid. The anticoagulant which is used also has an influence. For this reason it has been necessary to evolve a standard technique because one method is not strictly comparable with another. The sedimentation rate is influenced by the red-cell count. In the presence of a low red-cell count the sedimentation rate is increased.

Westergren's method

Westergren's method (1926) is the one most commonly used on the Continent. A tube of small bore is used and a solution of 3·8 per cent sodium citrate is the anticoagulant. Of this solution 0·4 c.c. is drawn into a Record syringe, the needle of which is then introduced into a vein and the plunger drawn out to the 2 c.c. mark. The mixture is then emptied into a specimen tube and should be manipulated without delay. The blood is drawn up into a standard Westergren tube (Fig. 75) which closely resembles a 1 c.c. pipette, but is calibrated in millimetres of length, the figures reading from above downwards and the calibration being carried to the extreme point. The zero mark is exactly 200 mm. from the point; the blood is drawn up to this mark. The tube is set upright in a stand in which a spring clip, pressing on the top, holds the point firmly against a piece of rubber at the lower end. The tube is now left to stand and the red corpuscles begin to settle down, leaving a clear supernatant plasma. The upper level of the red-cell column is usually sharp and distinct. The level of the red-cell column should be read at the end of one hour. The result is reported as the distance in millimetres sedimented by the top of the red-cell column. This should be stated in the report because some observers express their results as a percentage of total length. The distances sedimented by blood from a normal person are fairly constant. In men these are usually from 3 to 5 mm. at the end of the first hour and from 7 to 15 mm. at the end of two hours. In women and children the normal values are from 4 to 7 mm. in one hour and from 12 to 17 mm. in two hours. Figures of 30 to 35 mm. at the end of two hours are definitely pathological.

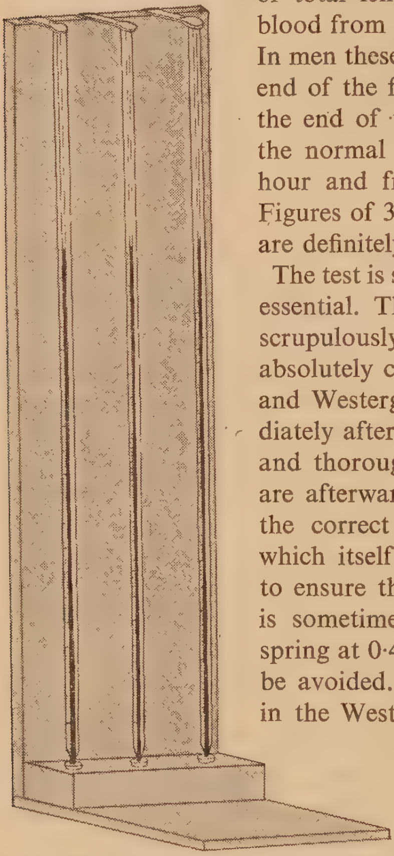


FIG. 75.—Westergren's sedimentation apparatus. (From *Disorders of the Blood*, by Whitby and Britton)

The test is so sensitive that an exact technique is essential. The following precautions should be scrupulously observed. All apparatus must be absolutely clean and the syringe, specimen tube and Westergren tube should be cleaned immediately after use by washing with soapy water and thoroughly rinsing with clean water; they are afterwards dried. It is important to obtain the correct dilution with the citrate solution, which itself must be accurately made. In order to ensure the correct dilution a special syringe is sometimes employed, which has a clicking spring at 0·4 c.c. and at 2·0 c.c.; bubbles should be avoided. It is important to set up the blood in the Westergren tube at the earliest possible moment; results after an hour or two of delay are never so reliable as those obtained immediately. Blood that has been allowed to stand overnight is quite useless. There must be no trace of coagulation, which completely invalidates the result.

Precautions A light tourniquet may be used to facilitate the venepuncture, but it must not be too tight and should be used for the shortest possible time. It is best to keep the tubes at room temperature whilst sedimentation is occurring; exposure to direct sunlight should be avoided. It is usual to carry out the test on patients in a fasting state, and in women it is advisable to avoid the times of the menstrual period as well as the few days before or after. Occasionally haemolysis may obscure the result. If haemolysis is marked the specimen should be rejected.

Micro-method

It is sometimes not possible to obtain the full 2 c.c. of blood, and in these cases a micro-method is permissible, but is not as satisfactory. When no vein is available, blood may be taken from a puncture wound by the following technique. A test-tube is marked at a level of 1·25 c.c. Into this tube is placed 0·25 c.c. of citrate solution. The hand or the foot is placed in a warm bath and then dried. A suitable site is punctured and the blood is allowed to fall straight into the citrate, being mixed by gentle shaking. This is continued until the blood reaches the 1·25 c.c. mark. By this method it is usually possible to obtain a full 200 mm. column. Proportionate dilutions may be used for even less quantities of blood, and in these cases a full Westergren tube cannot be filled, but a reasonable correction can be applied for a column not less than 50 mm. long.

Method of Zeckwer and Goodell

The method of Zeckwer and Goodell (1925) requires a larger volume of blood and a larger tube and the result is expressed in corpuscle or plasma volume. Two c.c. of 3·8 per cent solution of sodium citrate is drawn into a Record syringe, together with 8 c.c. of blood obtained from a vein. The citrated blood is placed in a 10 c.c. centrifuge tube graduated in tenths of a c.c. The tube is allowed to stand and the volume of corpuscles read off at the end of one hour and two hours. Certain investigators express the result by the volume of the supernatant plasma. All difficulties are avoided if the volume both of plasma and corpuscles is stated when making the report. Zeckwer and Goodell give the following average figures for normal persons and certain pathological conditions when using 10 c.c. of citrated blood.

	VOLUME OF RED CELLS AT THE END OF ONE HOUR
Normal – – – –	7 c.c.
Pregnancy – – – –	6 c.c.
Tuberculosis – – – –	4·4 c.c.
Acute inflammation – –	4·25 c.c.
Malignant disease – – –	4 c.c.

Experience shows, however, that 7 c.c. for the average normal is too small; 8·5 to 9 c.c. is more common. In a known case of tuberculosis a figure of 7 c.c. would suggest activity. There is no sharp demarcation between normal and pathological cases, and there are well-marked differences between individuals irrespective of a pathological condition; yet the result is remarkably constant for a particular person in health. Sedimentation is more complete in women than in men, and the phenomenon is more marked at the menses as well as during pregnancy.

Wintrobe's method

Wintrobe uses the haematocrit (p. 472) for the determination of sedimentation. The haematocrit, filled with oxalated blood, is allowed to stand in the vertical position. A reading may be made at frequent intervals or simply one single reading at the end of one hour. The precautions necessary are that the haematocrit should be absolutely vertical, the apparatus scrupulously clean, the temperature between

22° C. and 27° C., and the specimen of blood examined within four hours of the time of its collection. By Wintrobe's method the normal sedimentation for men, after one hour, is from 0 to 6·5 mm. with an average of 3·7 mm.; for women from 0 to 15 mm. with an average of 9·6 mm. The advantages of Wintrobe's method are that the haematocrit can afterwards be centrifugalized to determine the corpuscular volume (p. 474) and that the supernatant plasma is available for estimating the icterus index (p. 496).

2.–FRAGILITY OF THE RED CELLS

When suspended in saline solution the red cells do not normally lose any haemoglobin until the sodium chloride content of the fluid is reduced below 0·45 per cent. Fragility may be determined by qualitative and quantitative methods. Quantitative determinations give much more information than the simple qualitative test, because sometimes the only evidence of increased fragility is a greater degree of haemolysis at relatively low concentrations of saline.

Qualitative method

For the qualitative method an accurate 1 per cent solution of sodium chloride is required. Accuracy should be ensured by frequently checking the chloride content by titration. Four c.c. of blood is obtained from a vein without inducing stasis and is collected in 1 c.c. of 5 per cent sodium citrate dissolved in 0·6 per cent sodium chloride solution. The corpuscles are centrifuged and washed three times in 0·85 per cent sodium chloride solution. The following amounts of 1 per cent sodium chloride solution and distilled water are added to a series of tubes:

Tubes	1	2	3	4	5	6	7	8	9	10	11
1 per cent NaCl (c.c.)	4·25	3·75	3·25	2·75	2·5	2·25	2·0	1·75	1·5	1·25	1·0
Distilled water (c.c.)	0·75	1·25	1·75	2·25	2·5	2·75	3·0	3·25	3·5	3·75	4·0
i.e. per cent NaCl	0·85	0·75	0·65	0·55	0·5	0·45	0·4	0·35	0·3	0·25	0·2

0·05 c.c. (two drops from a standard gauged pipette) of the washed corpuscles are added to each tube. The tubes are inverted and allowed to stand for one or two hours. At the end of this time the supernatant fluid is examined and the occurrence of haemolysis noted. In normal blood, haemolysis is almost complete in tube 7 and quite evident in tube 6. A rough idea of the quantitative amount of haemolysis can be made by comparing the tint of the supernatant fluid with the tint of that found in a tube in which haemolysis is complete, by estimating the amount of sediment or more accurately by an actual determination of the amount of haemoglobin in solution. It is always advisable to put up a parallel test with normal blood as this provides a check upon the accuracy of the saline.

Quantitative method

The quantitative method (Whitby and Hynes, 1935) requires accurate solutions of sodium chloride ranging from 0·27 per cent to 0·72 per cent with intervals of 0·03 per cent; fragility can be determined by making dilutions of the blood in red-cell pipettes with each of the separate strengths. A count of the cells which do not haemolyse gives an accurate quantitative estimation of the amount of fragility. The result can be plotted as a graph. The sodium chloride solutions must be standardized with 3 per cent silver nitrate solution.

Interpretation

Fragility is definitely increased in most cases of acholuric jaundice. In adults particularly, the amount of increase may be small and is only evident when a quantitative test is performed. It is estimated that from 5 to 10 per cent of cases do not exhibit the phenomenon of increased fragility. In acholuric jaundice splenectomy usually has no influence on the fragility. Splenectomy, for diseases other than acholuric jaundice, causes a decrease in fragility, and this same resistance to saline haemolysis is found in obstructive jaundice.

Any obscure anaemia in which there is a constant reticulocytosis is worthy of investigation for fragility.

3.—BILIRUBINAEMIA

Gross bilirubinaemia is usually a symptom of obstructive jaundice. Minor grades, particularly when the type of bilirubin is that detected by an indirect van den Bergh reaction (see p. 496) and an icterus index between 5 and 15 are characteristic of the so-called haemolytic types of anaemia. The test is of importance in acholuric jaundice, malaria, haemolytic anaemias of the new-born, anaemias due to infection, Lederer's anaemia and pernicious anaemia. In the last named the bilirubinaemia is due, not to haemolysis, but to failure to utilize iron pigment derived from corpuscles that have been destroyed by normal processes; the bilirubinaemia disappears rapidly with liver treatment.

Van den Bergh reaction

The van den Bergh reaction must be made within about two hours of taking the blood, or paradoxical results are obtained. Ten to fifteen c.c. of blood are collected in an oxalated tube. The tube is prepared by taking 0·2 c.c. of 10 per cent potassium oxalate solution and evaporating to dryness. The tube containing blood is centrifugalized and the clear supernatant plasma is pipetted off. A sample taken for corpuscular volume (p. 474) can be used.

Solutions

(1) A freshly prepared solution of Ehrlich's diazo reagent. This is made from the two following solutions, which are kept separate until required:

A.	Sulphanilic acid – – –	1 gram
	Hydrochloric acid – –	15 c.c.
	Distilled water – – –	1,000 c.c.

B.	Sodium nitrite	0·5 gram
	Distilled water	100 c.c.

The complete reagent is made by mixing 25 c.c. of solution A and 0·75 c.c. of solution B.

(2) Absolute or 96 per cent alcohol

The direct reaction

For the direct reaction three small tubes are set up (numbered 1, 2 and 3) and 0·25 c.c. of oxalated plasma is pipetted into each. To the first tube, the control, 0·2 c.c. of water is added, whilst into No. 3 a small flake of caffeine and sodium salicylate is dropped; this accelerates the development of the colour change. After the salt has been dissolved by shaking, 0·2 c.c. of fresh diazo reagent is added, when a prompt and definite reaction takes place, shown by the production of a purple tint. When this colour has attained its maximum, 0·2 c.c. of the diazo reagent is added to tube 2 and any alteration in colour is compared with the fully developed reaction in tube 3. One of three events may occur in tube 2:—

Immediate direct reaction: This begins at once and reaches a maximum in ten to thirty seconds. The mixture turns to a bluish-violet colour, the intensity varying with the concentration of bilirubin.

Direct delayed reaction: Here a reddish colour, deepening to violet, begins to appear in about fifteen minutes.

Direct biphasic reaction: In this type of response a reddish colour appears immediately and takes much longer to deepen into a violet hue.

The indirect reaction

If no reaction is obtained, the indirect test should be carried out. To 1 c.c. of plasma 0·5 c.c. of diazo reagent is added, and, after a minute or so, 2·5 c.c. of 96 per cent alcohol and 1 c.c. of saturated aqueous ammonium sulphate solution. After thorough mixing, the tube and contents are centrifugalized, and the supernatant clear fluid can be used for quantitative colorimetric analysis. If the colour be too deep it may be diluted with alcohol, 2 parts of alcohol to 1 of the solution.

Icterus index

For the determination of the icterus index clear serum or plasma is used. The colour of the plasma is compared in a colorimeter with a standard 1 in 10,000 solution of potassium bichromate in distilled water. With a normal serum it is advisable to make a dilution of the serum with an equal quantity of saline; this renders the colour matching easier. When the serum contains much bile still further dilution is required. The colorimeter is set at 15 and matching carried out. The calculation is performed with the formula

$$\frac{15}{\text{Reading}} \times \text{by dilution of the serum} = \text{the icterus index.}$$

The serum or plasma must be unclouded and quite free from the products of haemolysis. The sample of blood should, therefore, be taken when fasting. Carotinaemia prohibits the performance of the test. The normal icterus index lies between 4 and 6. Jaundice is not obvious until the index reaches 15. Readings between 6 and 15 indicate latent jaundice. If a colorimeter is not available, a series of dilutions of potassium bichromate of known strength may be prepared in sealed tubes and a direct comparison made with these. Alternatively the colour of the plasma is compared with the colour of the standard, by placing unknown and standard solutions in tubes of the same bore. If the unknown is more yellow than the standard, 1 c.c. of the unknown is diluted with saline, adding 0·5 c.c. at a time until the colour matches the standard; the dilution corresponds to the icterus index, e.g. if the plasma has to be diluted 1 in 5 to obtain a match the icterus index is 5.

4.–CHEMICAL ANALYSIS

Collection of the specimen

Chemical analysis can only be accurate with an adequate specimen. As a rule for a general analysis a sample of 10 to 20 c.c. of blood is required. For a single analysis 3 c.c. will suffice for a blood-sugar, 4 to 5 c.c. for a blood-urea estimation, but 10 c.c. is required for blood-calcium or blood-cholesterol.

Oxalated specimens should be submitted for almost all chemical tests except blood calcium. The addition of oxalate prevents clotting by precipitating the blood calcium as calcium oxalate; calcium cannot therefore be estimated in an oxalated specimen. With regard to blood-sugar there is considerable glycolysis in a specimen which is delayed in transit so that the result of analysis is a low and unreliable figure. Specimens for blood-sugar that are subject to delay should have one drop of neat formalin added; this prevents glycolysis but renders the sample unsuitable for urea analysis.

Sodium or potassium oxalate is generally used for preventing coagulation but the citrates are equally good. Excess of anticoagulant should be avoided. The ideal quantity is 4 mg. of oxalate powder or 6 mg. of citrate per 10 c.c. of blood. For practical purposes a reasonable pinch of either powder is sufficient for 10 c.c. of blood or double the quantity for 20 c.c. Specimens of blood should be well shaken to ensure solution of the anticoagulant.

VI.—PARASITES

168.] The parasites found in human blood include the plasmodia of malaria, filariae, borrelia of relapsing fever, leptospira of Weil's disease, trypanosomes, leishmania of kala-azar, *Bartonella bacilliformis* and larvae of *Trichina spiralis*.

Malaria

Plasmodia. If the parasites are numerous an ordinary blood film is stained by Leishman's method and examined with the $\frac{1}{12}''$ oil immersion lens. The inexperienced should be careful not to mistake a blood platelet lying on top of a red corpuscle for a malaria parasite. The administration of quinine rapidly clears the blood of parasites; a negative examination within forty-eight hours of taking quinine should be expected. If the parasites are scanty the thick film method may be employed. In this method a drop of blood is smeared with a pin over about 1½ square inches of a slide and is allowed to dry for twenty to thirty minutes in the incubator. In order to lake the blood the slide is then immersed in a petri dish containing a solution of 2 per cent formalin and 1 per cent glacial acetic acid. This process must be carefully performed in order not to detach the film. The slide is then well washed in distilled water and stained with Giemsa's stain (one drop of stain to 1 c.c. of water) for twenty to thirty minutes, washed in water and allowed to dry without heating or blotting. All films that are to be examined for malaria parasites should be as fresh as possible otherwise the eosin does not stain with the desired intensity.

In patients whose blood contains small numbers of parasites it may be advisable to use some provocative method for increasing their number. This is effected by the subcutaneous injection of 1 c.c. of 1 in 1,000 adrenaline hydrochloride solution. The parasites appear in the blood about twenty minutes after injection and are maximal in about two hours. Ergot and strychnine are said to produce the same effect. Crescents may be concentrated by the method given below for filarial larvae.

Filariasis

Filariae. Puncture the finger of the patient during the night and also during the day-time. Place one drop of blood on a slide, smear the edges of a cover-slip with vaseline and drop it on to the blood. Examine the film first with the ⅔″ objective in order to detect the lashing movements of the parasite. Then examine the worm itself, with the ⅙″ objective. The slide may also be stained by Leishman's method. The parasite may be demonstrated by a concentration method. Receive about 1 c.c. of blood from a puncture of the ear or finger into 5 c.c. of 2 per cent acetic acid. Mix, centrifuge and examine the deposit either moist or after drying, fixing and staining with haematoxylin. The number of parasites in capillary blood is greater than that in venous blood.

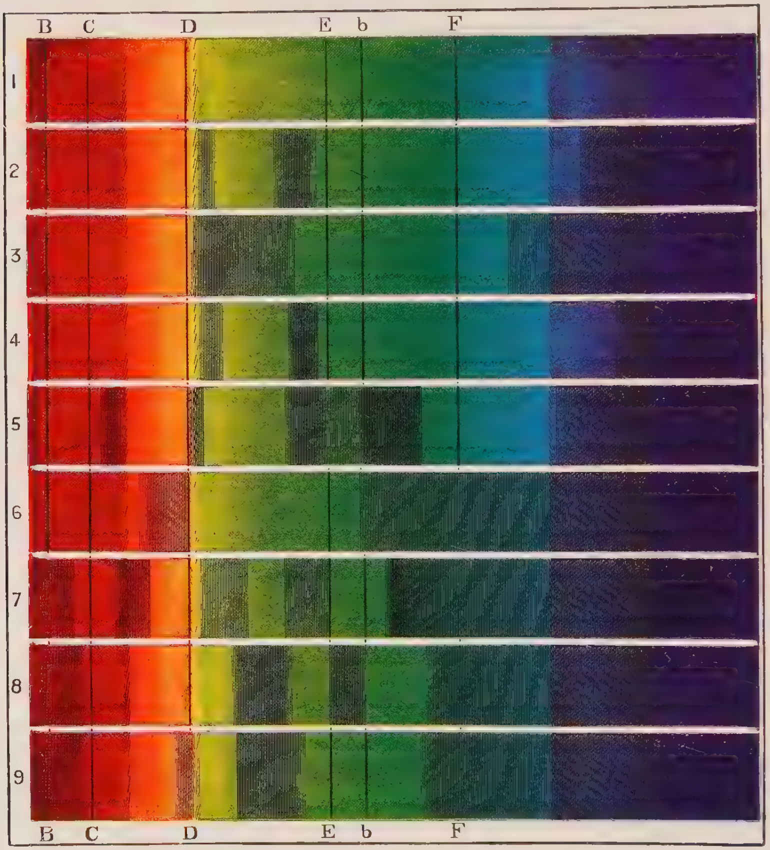
Relapsing fever

Borrelia of relapsing fever. Examine blood smears stained by Leishman's method. A wet preparation should also be examined under dark-ground illumination. The blood should be obtained during the pyrexial period. With wet preparations care should be taken not to exert too much pressure on the cover-slip, otherwise artefacts known as 'blood streamers' may be expressed from the edges of the red cells. If these become detached, any slight movement of the film is sufficient to impart to them the appearance of motility.

Leptospirosis

Leptospira icterohaemorrhagiae of Weil's disease. It is unusual to demonstrate the leptospira by a direct examination of a blood film. It is customary to inoculate 5 c.c. of citrated blood into a guinea-pig and to examine the animal for jaundice over a period of several days. When death occurs the liver may be examined for spirochaetes by dark-ground illumination, by Fontana's silver stain or by Congo red stain.

BLOOD-SPECTRA COMPARED WITH SOLAR SPECTRUM



1. Solar spectrum.
2. Spectrum of dilute solution of oxyhaemoglobin.
3. ,, ,, reduced haemoglobin.
4. ,, ,, carboxyhaemoglobin.
5. ,, ,, acid haematin in ethereal solution.
6. ,, ,, alkaline haematin.
7. ,, ,, methaemoglobin.
8. ,, ,, reduced haematin (haemochromogen).
9. ,, ,, acid haematoporphyrin.

(From *Handbook of Physiology*, by Halliburton and McDowall)

PLATE VI

[*To face p.* 499

Trypanosomes. In rare cases examination of a human blood film is sufficient to demonstrate the parasite. In other cases gland puncture and examination of gland juice is necessary. Such preparations are stained by Leishman's method. More often it is necessary to collect 10 c.c. of citrated blood and inoculate it intraperitoneally into a guinea-pig. Blood films are made from the animal's blood after ten to fourteen days and from 0·5 to 1 c.c. of the guinea-pig's blood is then inoculated into a mouse. The blood of the mouse should contain parasites after three to ten days. The appearance of the trypanosome in the guinea-pig's blood in numbers sufficient to be easily detected in a film is often a matter of some weeks.

Trypanosomiasis

Leishmaniae. The disease is characterized by a blood count which shows a very marked leucopenia with a polymorphonuclear decrease. Blood films should be examined for the presence of parasites in polymorphonuclear cells and monocytes. Leishman's stain is used. Leishman-stained films of material obtained by splenic puncture give a higher percentage of positive results.

Leishmaniasis

Bartonella bacilliformis. This organism is found within the red blood-cells and in severe cases may be present in large numbers. In mild cases long search may be necessary. Blood films stained by Leishman's method show rod-shaped organisms, 1μ to 2μ in length and 0·2μ to 0·5μ thick, contained within red cells. A cell may contain as many as ten parasites. The organisms show a polar staining effect; some forms are oval or pear-shaped.

Bartonellosis

Larvae of Trichina spiralis. Larvae can frequently be detected in the peripheral blood from the sixth day after the onset of symptoms to about the twentieth day; that is, the period during which migration from the intestine to the muscles is taking place. Five to ten c.c. of blood are obtained from a vein and received into 50 to 100 c.c. of 2 per cent acetic acid. Mix well, centrifuge and examine the deposit. The larvae are easily recognized, being some 125μ long and 6μ broad.

Trichiniasis

VII.—MISCELLANEOUS

1.–HAEMOGLOBIN DERIVATIVES

169.] The principle underlying the science of spectroscopy is that when white light passes through a solution of a given substance certain colours are absorbed which differ according to the nature of the substance. Absorption causes dark bands or lines to appear on the ordinary spectrum, and the position, number and intensity of these bands in relation to the Fraunhofer lines may be used for diagnosis. A small direct-vision spectroscope is sufficient for ordinary laboratory purposes. The solution, which must be absolutely clear, is examined against bright daylight and the relation of the absorption bands of the Fraunhofer lines is

Spectroscopic examination

determined. The Fraunhofer lines should be clearly focused by adjusting the width of the slit and the eyepiece.

Any fluid which can be cleared by filtration or centrifugalization, such as urine, pleural fluid or fresh blood, may be examined directly for oxyhaemoglobin and methaemoglobin. The best results are obtained when the fluid is carefully diluted with distilled water until the optimum clearness of the absorption bands is obtained. The complete proof that the material contains a derivative of haemoglobin is obtained by treating the specimen with ammonium sulphide or Stokes's solution (ferrous sulphate 2 grams, tartaric acid 3 grams, water 100 c.c.: for use, to a few c.c. of this solution add strong solution of ammonia, drop by drop until the precipitate is just dissolved).

These reagents convert oxyhaemoglobin and methaemoglobin, which latter resembles acid haematin, into reduced haemoglobin. Haematin in acid solution is converted into haemochromogen with a very characteristic spectrum. The position of the absorption bands of the various haemoglobin derivatives is shown in Plate VI.

For examining dried blood stains, the stain should be extracted in 1 to 2 c.c. of 10 per cent caustic soda warmed to about 90° C. After cooling, ammonium sulphide or Stokes's reagent is added and the solution then examined for haemochromogen. If the stains are very old, the haemoglobin will probably be in the form of haematoporphyrin. This may be extracted with a few drops of strong sulphuric acid.

2.–BLOOD VISCOSITY

Variation in the viscosity of the blood influences the load carried by the heart. Increased viscosity may be regarded as an indication that bleeding will be beneficial. Viscosity is reduced when the blood count is reduced, as in primary or secondary anaemia, and also in oedematous states as well as sometimes in leukaemia and malaria. Viscosity is increased in conditions of cyanosis, polycythaemia, diabetes mellitus, icterus, and sometimes in pneumonia. Profuse sweating without any opportunity to replace the lost fluid raises the viscosity by 25 to 30 per cent. Vomiting and diarrhoea have the same effect (see article on CHOLERA).

When determining the viscosity of the blood, comparison is made with distilled water. Blood is normally 4·8 to 5·2 times as viscid as water. Determinations are carried out with an apparatus known as a viscosimeter or stalagmometer. A number of methods are described in the *Folia Haematologica* (1907). Several forms of apparatus are on the market and instructions for their use are supplied with them. As the viscosity varies in proportion to the red-cell count and haemoglobin content, these should always be determined at the same time.

3.–BLOOD VOLUME

Blood volume varies with height, weight, and especially surface area. The volume ranges from 4,000 to 8,000 c.c. in normal adults with an average of 87·7 c.c. for each square metre of body surface. The blood volume (plasma volume) is increased in nephrosis, erythraemia (polycythaemia vera), leukaemia, cirrhosis of the liver, acholuric jaundice and Banti's syndrome; the volume is decreased in anaemias although there is a relative increase in plasma volume. The volume is often low or normal in hypertension, thus contradicting the doctrine of plethora, and also in glomerular nephritis (so-called hydraemic plethora). The blood volume and the plasma volume are increased in the late stages of pregnancy.

Polycythaemia may be caused by a low plasma volume, but if there is also a high plasma-volume then plethora co-exists.

Method of Rowntree, Brown and Roth (1929): Inject intravenously either 8 or 10 c.c. of neutral red dye made up as a 1·5 per cent solution in freshly distilled water. The solution is sterilized by boiling for five to ten minutes. It should be made up freshly when required. Before injecting the dye, withdraw 10 c.c. of blood from a vein and place this in a graduated centrifuge tube with sufficient sodium oxalate to prevent coagulation. The plasma from this specimen of blood is used for preparing the standard for the purposes of comparison. Inject into the same vein the dye solution (either the amount named above or 3 mg. of the dye per kilogram of body weight; the weight in pounds, divided by 11, gives the number of c.c. of a 1·5 per cent solution to be injected). Three minutes later withdraw 10 c.c. of blood from a vein in the opposite arm without inducing stasis; two or three minutes later withdraw another sample of 10 c.c. Oxalate both samples in order to prevent clotting. Centrifugalize the three samples in graduated 10 c.c. centrifuge tubes at 3,000 revolutions per minute for twenty minutes. Read off the relation of the cells to the plasma. Prepare a standardized plasma solution for comparison in a colorimeter; 0·5 c.c. of the dye used for injection is made up to 100 c.c. with normal saline and 1 part of this is mixed with 1 part of the first sample of plasma and with 2 parts of saline, giving a dilution of 1 in 4. Each of the second and third specimens of plasma is diluted with 3 parts of saline and the colour compared with the standardized plasma solution. Heparin may be used instead of oxalate to prevent coagulation. A period of rest is advisable before injection of the dye. If haemolysis occurs the determination must be repeated. Occasionally the dye has a toxic effect. The main difficulty for accurate work is to withdraw the samples of blood before the dye begins to be excreted. If the samples are taken within six minutes this last difficulty is usually avoided.

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BLOOD GROUPS

See BLOOD TRANSFUSION, p. 530

BLOOD-PRESSURE, HIGH AND LOW

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Reference may also be made to the following titles:

APOPLEXY
ARTERIAL DISEASE AND DEGENERATION
NEPHRITIS AND NEPHROSIS

1.–PHYSIOLOGICAL BLOOD-PRESSURE

Definition

170.] Blood-pressure is the pressure exerted by the blood at a given instant upon a given point in the circulatory system, whether within the heart, arteries, capillaries or veins.

Factors concerned in its maintenance and variation are: (1) the force of the heart beat, variable and intermittent; (2) the peripheral resistance, variable and continuous; (3) the capacity of the arteries for recoil after distension of their walls; (4) the volume of the circulating blood; and (5) the viscosity of the blood.

The function of the circulation is to maintain an adequate flow of blood through the capillaries of the various organs and tissues, and thereby to provide nutriment and oxygen sufficient for the varying demands of the body. The needs of local areas are regulated by variations in calibre of the smallest arteries. Such variations would be ineffective were not a constant head of pressure maintained in the main artery. Hence an adequate blood-pressure is essential to life.

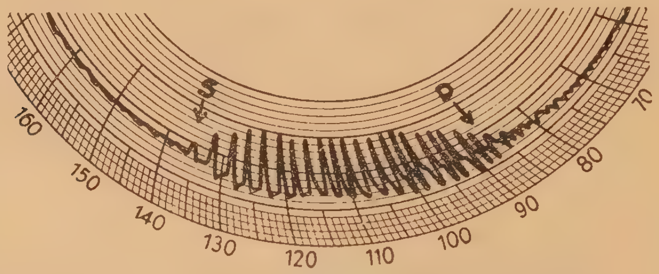

FIG. 76.—Tonoscillogram of normal blood-pressure in a healthy man aged 53. Systolic pressure, 135 mm. Hg; diastolic pressure, 86 mm.

The term blood-pressure has come to be generally used in the limited sense of intra-arterial pressure, which is a force originated by ventricular contraction, maintained by resilience of the arterial walls, and regulated by the degree of resistance in the peripheral portion of the arterial system.

Age

Many factors, of which age is one of the chief, induce physiological variations. During the first month of life blood-pressure rises rapidly, but the rise becomes more gradual during the remainder of infancy and childhood. During puberty and adolescence, when growth and development are rapid, blood-pressure again rises, to be succeeded by a slight fall in the next two or three years. After physical maturity, the average blood-pressure of healthy persons rises but little with advancing years until old age is reached. During the second half of life the normal rise of systolic blood-pressure does not amount to more than 15 mm. But although the modal (typical) blood-pressure does not vary from youth to old age, the average blood-pressure in the latter shows some progressive rise through inclusion of figures which approach upper limits of normality. Since this rise is chiefly in systolic pressure, and the diastolic pressure shows little variation, it is probable that the majority of cases occur in association with arteriosclerosis and should be excluded from a normal series.

Constitutio

Blood-pressures, systolic and diastolic, vary directly with the type of bodily constitution, as expressed by weight and height. Body-weight has a greater influence than height. In a series of 3397 unselected patients, thin, normal and obese, analysed by Gager and Hurlin, the various age groups manifested blood-pressures that were higher as weight increased. Life insurance statistics show that after the age of forty-five applicants who are more than 25 per cent overweight, and whose blood-pressure is 25 mm. above the average, have a mortality rate twice the normal.

Sex

Up to the age of puberty blood-pressure in both sexes is approximately equal. At puberty a sex difference becomes manifest, and from adolescence to the age of forty years men have a systolic pressure about 8 mm. higher than women. In women, with the onset of the menopause, the systolic pressure becomes equal or higher, while diastolic pressure for the next ten years remains much the same; at the age of fifty diastolic pressure rises rapidly, and continues to be substantially higher than that for men.

Exercise

The effects of muscular exercise vary with the individual and with the amount taken. Slight exercise, especially in those accustomed to it, causes little or no variation in pressure. In healthy young adults strenuous exercise, such as running or climbing stairs, will often induce an elevation to 180 mm. or more in systolic pressure, with either a decided drop in diastolic pressure through vasodilatation in the muscles activated, or a slight rise through augmented cardiac output and rate, as in an effort-tolerance test. On resting there is a quick drop to normal within a few minutes. In men accustomed to hard muscular work and in healthy athletes, arterial pressures are below the average. Too strenuous or prolonged exercise causes a brief initial systolic rise followed by a fall. The better the training for the particular form of exertion, the less the pressure rises, so that athletes as a rule have lower blood-pressures than other persons of equivalent ages and physique.

Posture

The influence of change from a reclining to a sitting or standing posture is not yet clearly determined; the effects appear to be slight.

Digestion

A slight rise in systolic pressure accompanied by a drop in diastolic pressure appears to coincide with the intake of food. During active gastric secretion, systolic pressure falls, but rises again when food passes on into the intestines. During fasting, both pressures show gradual decline with a speedy return to normal when food is taken.

Altitude

Moderate changes in altitude and barometric pressure cause little variation in blood-pressure in healthy subjects, any rise in systolic pressure being associated with the rapidity rather than the extent of alteration in atmospheric pressure. For aviation a responsive and resilient vascular system is essential. Flying at high altitudes produces different effects upon blood-pressure and circulation in different individuals.

Menstruation For one or two days preceding menstruation, the blood-pressure is slightly raised; when the period becomes established there is a fall, and towards the end another rise.

Pregnancy During the first two-thirds of normal pregnancy blood-pressure shows little change, but in the last few months there is a slight rise. During labour there is a progressive elevation of blood-pressure, even to considerable heights as the pains become more intense, reaching a maximum as the head of the infant is expelled. After delivery the pressure rapidly falls.

Psychical factors Emotions such as excitement, fear, joy, grief or anger, and mental states such as worry and concentration, all raise systolic pressure temporarily, sometimes to inordinate heights: the diastolic pressure is far less influenced. With persistence of emotions or mental impressions, pressures tend to assume permanently high levels.

Combined stimuli, such as pain and cold, exert an effect on both pressures. There is no blood-pressure figure characteristic or constant for any individual, since not only are there diurnal variations related to activity and rest, but pressures may fluctuate from minute to minute even during the brief time required for investigation.

Waking and sleeping During waking hours blood-pressure tends to rise. In quiet sleep both pressures are low, the systolic being usually about 94 mm. in men, and 88 mm. in women. The diastolic drop is less than the systolic, probably as a result of peripheral arteriolar dilatation and lessened ventricular energy and rate combined with mental and physical repose. Similar effects of less degree are observed in the resting state.

Systolic and diastolic pressure The significance of systolic, diastolic, mean and differential blood-pressures will now be considered. The heart may be likened to a central pump. Within the arteries there is a sequence of pressure waves each consisting of a peak followed by a depression. The crest of the wave, coinciding with active contraction of the heart (systole), is called the maximal or systolic pressure, and the base of the wave, coinciding with the resting state of the heart (diastole), is called the minimal or diastolic pressure. Of the two pressures the diastolic is by far the more important, because it is a measure of the burden which the arteries and aortic valves must continuously bear throughout life; the systolic pressure represents only an intermittent and additional load, varying within wide physiological limits in response to the various needs and activities of the body, being raised by psychical and physical stimuli, and lowered by rest, quiet sleep, fasting and fatigue. Further, the diastolic pressure is of great significance as a measure of peripheral arteriolar resistance and of vasomotor nervous tone.

Mean pressure The mean pressure is not the arithmetical mean between the diastolic and systolic pressures, but is the average pressure which, in a pulse tracing, often (but not necessarily) appears nearer the diastolic than the systolic level. In practice, the mean pressure is the pressure within the armlet which corresponds with the largest oscillation (the oscillometric index), and is equal to the pressure measured by arterial puncture in 70 per cent of cases. Great value is ascribed by the French school to the mean pressure, but circulatory efficiency cannot be assessed on a consideration of this pressure alone.

Differential or pulse pressure

By subtracting the figure for the diastolic pressure from that for the systolic we obtain a figure for the differential or pulse pressure. Any notable deviation from the standard figure of 44 mm. Hg, taken in conjunction with the height of the diastolic pressure, implies that the cardiac load is either augmented or diminished.

Interpretation of results

From statistics of normal range of blood-pressure in great numbers of healthy persons, tables of standard arterial pressures for adults of medium physique at various ages have been made. Physiological deviations from these standards, usually moderate, but occasionally large, may occur. Furthermore, at a given age or in certain circumstances, figures that are physiological for one individual may be pathological for another.

A widespread notion that the normal systolic pressure of an adult can be arrived at by adding 100 to the age in years has come down from the early days of blood-pressure estimation, and need only be mentioned to be condemned. While tables of standard pressures are valuable as a general guide, it should be borne in mind that the variations that may occur in normal subjects are such that, unless the figures can be interpreted in the light of considerable experience, tables may be more misleading than helpful. Systolic pressure, for example, under conditions of health may rise as high as 190 mm. Hg, or fall as low as 85 mm.; unless persistent, such fluctuations are usually of no serious import.

Hence the scope of physiological variation makes caution necessary in interpreting a blood-pressure reading. An opinion as to whether a given pressure is abnormally high or low for an individual is never easy to give, and often cannot be vouchsafed on the results of a single blood-pressure estimation.

2.—CLINICAL ESTIMATION OF BLOOD-PRESSURE

Sphygmomanometers

The level of the blood-pressure is measured by the sphygmomanometer. The brachial artery is alternately compressed and decompressed by an armlet containing an inflatable rubber bag connected with a pressure gauge. Sphygmomanometers are of two main varieties, mercurial and aneroid. The most reliable and accurate is a properly calibrated mercurial sphygmomanometer. For special investigations self-recording instruments have come into use which afford graphic and permanent records of arterial pressures and individual pulse characters.

Technique by the auditory method

For accurate and reliable information the blood-pressure reading should be taken, under standard conditions, when fasting or not less than two hours after a meal, with the subject physically and mentally at rest. The room should be quiet and comfortably warm, the cuff evenly adjusted as high above the elbow as possible, and the subject relaxed, with the bared arm lying passive on a table conveniently placed so that the cuff is at heart-level. Apprehension on the part of the subject should be allayed. The air-bag should be inflated to a point well above that at which any sound is audible by the stethoscope adjusted with its bell over the brachial artery. The pressure in the bag is then gently allowed to fall, and the first sharp click heard during deflation is the auditory index of systolic pressure. The external pressure is lowered further and the point at which the first dull, muffled sound takes the place of the previous sequence of loud thudding sounds marks the level of the diastolic pressure. This point coincides with the beginning of the fourth phase of sound, which is of variable duration and of no clinical significance. The first reading or two is of little value, and estimations should be made in quick succession on the upper limb of the same side in order to arrive at the lowest constant reading at the time of estimation. This approximation to the basic pressure is what one wants to determine.

The complete data should be recorded in the case notes as a set of figures representing systolic pressure, diastolic pressure, differential pressure, pulse rate and characters.

3.–HIGH BLOOD-PRESSURE

(*Synonyms*.—Hyperpiesis; hypertension. The term 'hypertension', although widely accepted, is open to question on the grounds that (1) it is a hybrid compounded of Greek and Latin derivatives; (2) 'tension' is a property of the arterial walls, but not of the contained blood in the ordinary sense. Allbutt first used 'hyperpiesis' as a synonym for raised blood-pressure. Later he employed 'hyperpiesia' for high blood-pressure and the associated clinical state.)

Definition

High blood-pressure is a circulatory state, arising from any cause, in which the pressure of blood within the arteries becomes elevated beyond normal limits. In general, the term includes any raised arterial pressure, whether temporary, intermittent, paroxysmal or permanent; involving systolic pressure, diastolic pressure, or both; of renal or non-renal origin.

Clinical varieties

High blood-pressure is the symptomatic expression of some underlying cause or causes as yet imperfectly understood; it occurs in the following forms:

A. Essential Hypertension
    (a) Slight or moderate—'benign'
    (b) Severe and rapid—'malignant'
B. Other Forms of Hypertension in relation to
    (a) Constitution
    (b) Cardiac disease
    (c) Renal disease
    (d) Endocrine glandular disorders
    (e) Increased intracranial pressure
    (f) Obesity

(1)—Essential Hypertension

[*Synonyms.*—Hyperpiesia (Allbutt); presclerosis (Huchard); hypertensive cardiovascular disease (Janeway)]

(*a*) *Definition*

Essential hypertension is characterized by sustained and progressive elevation of both systolic and diastolic blood-pressures, with or without symptoms; in its later stages it is associated with cardiac hypertrophy and vascular changes in the brain and kidneys, but not usually with renal insufficiency.

(*b*) *Aetiology*

The immediate cause is unknown. It is still doubtful whether essential hypertension should be looked upon as a primary disease, in accordance with Allbutt's original description, or as an arteriolosclerosis of non-renal origin, or as of renal origin. There is general agreement that the main seat of rise in systemic arterial pressure lies in the smooth muscle cells of the arterioles which enter into a state of 'functional' vasoconstriction or spasm. The precise mechanism by which this is brought about is not yet established. The most recent work is that of Pickering, followed closely by Prinzmetal and Wilson, who find that under similar environmental conditions the rate of blood-flow through the forearm is the same in subjects with essential hypertension, malignant hypertension, and chronic nephritis with hypertension as in subjects with normal blood-pressures. The increased vascular resistance is such that, if generally distributed throughout the body, it would account for the levels of pressure observed. By warming the body, vasoconstrictor nerve impulses to the cutaneous vessels of the hands are completely inhibited, and since in persistent hypertension the rate of blood-flow is never greater, but sometimes less, than its value in normal subjects of similar age, it is concluded that the abnormal agent narrowing the vessels is not primarily nervous. 'Any comprehensive theory of the mechanism of essential, malignant, and chronic nephritic hypertension must account not only for the raised pressure but for the intimal lesions in the smaller arteries. . . . The presumably chemical abnormality which leads to vasoconstriction may also play some part in the genesis of the intimal thickening in the smaller arteries which so often determines the course of the disease' (Pickering).

Disposing causes are as follows:

Heredity Hereditary and familial factors are clearly recognizable, often related to cerebral haemorrhage and angina pectoris of coronary origin at comparatively early ages. Several members of one generation may be affected, and a history of vascular disease or high blood-pressure may be elicited in one or two preceding generations, such hereditary and familial incidence involving both sexes.

Constitution The condition is most frequently encountered in those of robust build, often plethoric, with broad and deep chests, big bones and a tendency to put on weight. Gout and diabetes are not uncommon in such subjects. Another type is short and stocky, bull-necked and soft-muscled. In both of these groups arteriosclerosis of mild type and labile blood-pressures occur. In women this kind of build is less definite. In another group the features are pale, indicative of active vascular constriction, with subsequent degeneration rather than sclerosis.

Age

Any age may be affected. Hyperpiesia may occur in children or, more often, in young adults. It is rare, however, below the age of thirty and is usually met with in subjects above middle age chiefly in the years between forty and seventy (90 per cent of cases).

Sex

Sex incidence is approximately equal. In private practice males appear slightly to predominate, whereas in hospital practice females are slightly in excess.

Race

In the pure-bred Chinese and in primitive African negroes essential hypertension is uncommon.

Psychical factors

In many persons psychical factors play a leading part in inducing transient or even sustained rises in blood-pressure, but whether these are primary or whether they merely activate an inherent constitutional disposition is still uncertain. Mental concentration apart from emotion has no appreciable effect on essential hypertension.

Relation to metabolism

In regard to the association of the disease with metabolic diseases such as gout, diabetes and obesity—apart from the influence of overweight in the latter—all that can be said is that a similar type of constitution is found in these disorders, but none of them can be invoked as aetiological. Again, hypercholesterolaemia, hyperglycaemia and lessened sugar tolerance are not infrequent in hyperpiesia, but have no causal connexion with its development.

(*c*) *Pathology and Pathogeny*

The medullary vasomotor centre

Most observers are of the opinion that hypertension results from variations in tonic activity of (*a*) the chief controlling centre in the medulla oblongata, induced both reflexly and by alterations in the chemical composition of the circulating blood, (*b*) other subsidiary centres in the thoracic region of the spinal cord, (*c*) the cerebral cortex. The stimulus has been attributed to various causes, such as augmented sensitiveness of the vasomotor centres, vascular injury, interference with oxidation, or arteriosclerosis of the medulla.

The autonomic-endocrine system

Under the control of the medullary vasomotor centre, regulation of the circulation is largely vested in the autonomic-endocrine system, the sympathetic division acting in conjunction with the pituitary, thyroid, adrenals and gonads, and exerting also a considerable influence upon metabolism, whereas the parasympathetic division has more limited associations with the parathyroids, and with the cell-islets of the pancreas over which direct vagus control has been proved.

The endocrine glands activate or depress circulatory mechanisms through the sympathetic by means of their hormones, pressor influences being exerted by vasopressin (posterior lobe of pituitary) and by adrenaline, while the cells of the pancreas furnish a depressor hormone, vagotonine.

The pituitary gland

In 1932 Harvey Cushing advanced the view that the posterior lobe of the pituitary possesses an active principle capable, among other properties, of raising arterial pressure and of diminishing renal secretion. His conclusion was that infiltrative basophilia of the pars nervosa of the pituitary gland is an expression of functional overactivation of the posterior lobe, and represents the pathological basis of hyperpietic disorders.

The chromaffin system

Although in hypertension the presence of excess adrenaline in the blood has not been established, it is probable that a flow of adrenaline into the blood from the cells of chromaffin sympathetic tissue in the adrenals and elsewhere in the body may activate the adjacent sympathetic system.

(*d*) *Clinical Picture*

Essential hypertension is a syndrome, which in the opinion of many observers amounts to a disease, attended by a distinct series of clinical and pathological phenomena, which arise independently of arterial, renal, cerebral or other demonstrable morbid change and, after a variable period of latency, manifest individual characters. The chief of these are high systolic and diastolic pressures—at first labile and later persistent though not necessarily permanent—and left ventricular hypertrophy.

Mode of onset

It is among the commonest of diseases. Its onset is insidious, many subjects for long periods being unconscious of any disability, or ignoring slight symptoms which they ascribe to causes unconnected with the condition. Usually the condition is already well established by the time the patient seeks medical advice.

If one excludes associated conditions, high blood-pressure alone gives rise to no symptoms.

Sympathetic vaso-constriction

In view of the action of the sympathetic nervous system in regulating the calibre of the arterioles, and inducing vasoconstriction over large areas with resulting rise of blood-pressure, it is not surprising to find a history of ill-defined vasomotor manifestations during the latent period of variable duration which precedes, sometimes for years, the elevation of blood-pressure. These indefinite symptoms are of the nature of a vasoneurosis, and include coldness in the extremities, digestive disturbances, malnutrition, effort-dyspnoea and palpitation, fatiguability, pressure headaches, hemicrania, occasional noises in the head and defective vision. Observation over long periods of time shows that in a certain proportion of subjects manifesting these symptoms high blood-pressure becomes added to the syndrome.

Similar manifestations may also form part of the early stages of hypertension and may be combined with the following subjective sensations in order of frequency: fullness, heaviness or throbbing in the head aggravated by mental stress, dizziness, flushing, precordial pain, drowsiness, disinclination for effort, impaired memory and concentration, irritability, anxiety states, neuralgia, migraine and epistaxis. The last may be an early as well as a late symptom.

Resemblance to psycho-neurosis

These symptoms are identical in incidence, character, frequency and duration with those found in cases of psychoneurosis with normal blood-pressures. A similar causation for the two conditions is further suggested by the fact that the symptoms frequently develop with emotional upsets or environmental difficulties and subside on their removal.

Relation of symptoms to blood-pressure

That the early symptoms are due directly to rise of blood-pressure is improbable, for (1) their amelioration often occurs apart from reduction in blood-pressure, (2) there is no parallelism between their intensity and the pressure increase, and (3) such increase is frequently discovered by chance during the course of life assurance or periodical health examination, in apparently robust people who feel in perfect health. Some patients suffer more from the knowledge that they have high blood-pressure than from the condition itself. Such 'hypertension hypochondriasis', as Osler termed it, is particularly common in the United States, where a morbid interest is often taken in the exact height of the pressure reading from day to day.

In later stages, the symptoms are those of the associated conditions—cerebral, cardiac and renal.

(*e*) *Course and Prognosis*

Course

According to the clinical course, essential hypertension may conveniently be divided into two contrasting forms:

Benign hypertension

(i) Slight or moderate, which together constitute over 90 per cent of the total number of cases; these are called 'benign'. Clinical manifestations are mild, and renal function is never greatly impaired. The high pressure accounts for most of the symptoms of headache, lassitude, cardiac pain and shortness of breath. The heart is hypertrophied, systolic pressure being often elevated to 200 mm. and diastolic to 120 mm. Cerebral haemorrhage may occur causing transient paresis and aphasia. Haemorrhage into the retina is also not uncommon.

Malignant hypertension

(ii) Severe, which comprise the remainder, and are classed as 'malignant'. Two main varieties occur:

(α) In subjects over middle age, with previous elevation of blood-pressure, benign in character, persisting for several years in conjunction with hypertrophy of the heart and arteriosclerosis. Without any apparent reason the patient becomes worse and complains of lassitude, loss of appetite, headache, giddiness and dyspnoea. Increased frequency of micturition, especially at night, points to the rapid onset of renal inadequacy; and visual disturbances mark the appearance of hypertensive neuro-retinopathy—the so-called 'albuminuric retinitis'. Such patients are usually between the ages of 40 and 50 years, death usually occurring within two years from the beginning of renal symptoms.

(β) In relatively young subjects, unaware of the previous existence of essential hypertension over an unknown period of time, who manifest the most acute and rapidly progressive renal insufficiency and neuro-retinopathy. The duration of symptoms may be reckoned by months rather than by years, and at autopsy confirmatory evidences are disclosed of previously long-standing high blood-pressure.

The malignant phase is heralded by considerable and advancing permanent hypertension in both these groups along with rapid progress of acute renal insufficiency. The corresponding histological picture shows necrosis and endarteritis of the renal arterioles, a further and terminal stage of arteriolosclerotic atrophy of the kidneys characteristic of most cases of essential hypertension.

Prognosis

Accuracy in the prognosis of essential hypertension depends upon clinical experience and balanced judgment, based on a correct use of the sphygmomanometer. Successive estimations are needed to determine whether a rise of blood-pressure is transitory or persistent. The personal equation of the patient is of importance; heredity, constitution, environment, body-weight, age, sex and temperament must all be taken into account.

Expectation of life

Prognosis has lately been made much easier by the study of collected life assurance statistics of more than a quarter of a million apparently healthy subjects. These records show that any rise of arterial pressure persistently higher than standard figures for age and body-weight materially increases the gravity of the outlook. Thus, a consistent elevation of 10 to 14 mm. in systolic pressure, or approximately 10 per cent above the average for age, increases by 36 per cent the expected mortality. Further rises above average levels are linked with a still higher death-rate, the expectation of life decreasing proportionately with the increase in blood-pressure. At the age of forty, for example, a rise of 35 to 49 mm. above the average increases the expected mortality by 148 per cent. With added signs of physical impairment, the outlook is still worse. The high death-rate associated with a diastolic level of 110 mm. or over coincides closely with that accompanying a systolic level of 200 mm. or over, the expectation of life being limited to a maximum of ten years. Systolic pressures over 220 mm. are usually fatal within three years, although notable exceptions even up to eleven years have been known. Gager remarks how active and free from symptoms many of these patients may be; they operate machines in factories, drive cars, play games, travel and occupy positions of responsibility.

Favourable features

The prognosis is most favourable when high pressure is discovered fortuitously, as in examination for life assurance, or when removal of severe emotional or mental stress brings relief. It is particularly good in subjects who are leading a full life with no disturbing symptoms or cardiac disability. A marked fall in pressure as a result of rest in bed or other remedial measures is a favourable sign. Early diagnosis is important, for complications can be modified and the mode of life adjusted to the condition; the ability of women to lead a quiet life often gives a better prognosis in them than in men of the same age.

Unfavourable features

Generally speaking, the younger the patient, the worse the prognosis. When the disease begins between twenty and thirty years of age it is apt to run a rapid and severe course, but there are many exceptions to this rule. Patients with very high blood-pressures, particularly diastolic, often do badly, and when the figures are above 250/150 the patient is always in danger. When there is degeneration in the heart, arteries and kidneys, the gravity of the prognosis varies directly with the extent to which these organs are involved.

The most weighty factor in individual prognosis is the state of the heart. Limited effort-tolerance and anginal pain on exertion are significant in proportion to their appearance on slight, moderate or prolonged exertion. Signs of definite cardiac failure are always of serious import, and gallop rhythm and pulsus alternans further enhance the gravity of the prognosis.

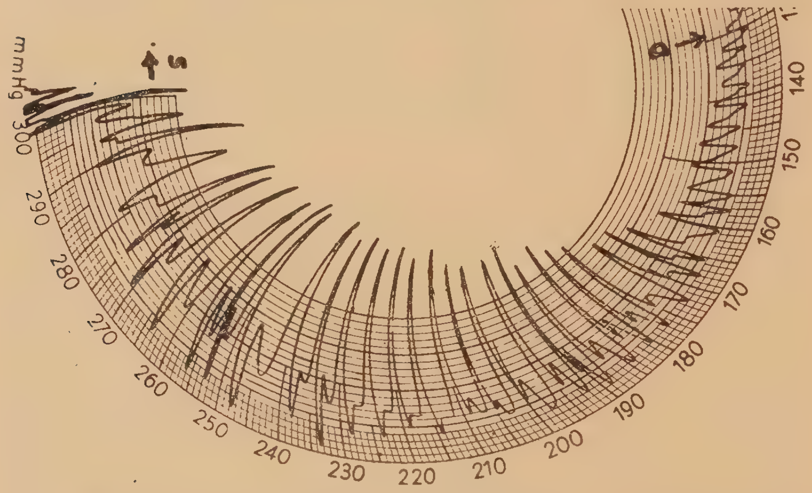

FIG. 77.—Tonoscillogram of extremely high blood-pressure in a woman aged 66. Hypertension in association with gout, cardiac dilatation following hypertrophy; arteriosclerosis with haemorrhage. Lived for 3 years after first recognition. Systolic pressure, 320 mm. Hg—recorded elsewhere (the tonoscillogram reading only up to 300 mm.). Diastolic pressure, 129 mm.

Causes of death

The course of the disease is very variable. Death may in some cases occur as soon as nine months after the first appearance of symptoms, or in others may be delayed for twenty or thirty years. The most frequent causes of death are circulatory failure (about 45 per cent), coronary disease (about 15 per cent), cerebral vascular sclerosis leading to cerebral haemorrhage, thrombosis and softening of brain substance (about 20 per cent), and terminal infections, notably pericarditis, pleurisy and pneumonia (about 2 per cent).

(2)—Other Forms of Hypertension

(*a*) *Aetiology*

From consideration of the numerous factors concerned in the maintenance and variation of blood-pressure, the causes that may possibly influence its elevation may briefly be reviewed.

Heart-rate

Apart from transient elevations due to exercise or emotion, the minute-volume of the heart is either normal or but slightly increased in many cases of persistently high blood-pressure, for neither quickening of the heart-rate nor increase in the heart output (stroke volume) is of itself sufficient cause.

Blood-volume and viscosity

Variations in blood-volume have no effect on normal blood-pressures, but where hypertension already exists a rise of blood-pressure may be dependent upon increase in blood-volume. No direct relation between blood viscosity and blood-pressure can be established even by the most exact modern methods. The weight of evidence goes to show that in persistent hypertension an increased resistance to the flow of blood through the vessels is not due to increased viscosity of the blood. In the majority of such instances the blood viscosity is normal, and in the higher grades of anaemia is less than normal.

Erythraemia

In erythraemia (polycythaemia vera) the blood-volume may be doubled, but as a rule the blood-pressure is but moderately raised. Polycythaemia hypertonica, described by Geisböck, has a syndrome of high blood-pressure and viscosity, arteriosclerosis, nephritis and frequent incidence of cerebral haemorrhage, with absence of splenic enlargement.

Arterial resiliency

Lessening of resiliency in the large arteries leads to increase in the systolic and decrease in the diastolic blood-pressure.

Spastic arteriolar constriction

Increase in the peripheral resistance from abnormal narrowing of the peripheral vessels is a factor of the highest aetiological importance. The force of each heart-beat is gradually broken down in overcoming frictional peripheral resistance, so that a high pressure at the level of the aorta becomes reduced to about one-tenth of the original height in the terminal capillary bed, with corresponding obliteration of the differential pressure. Damping-down of pressure takes place mainly in the arterioles, which not only reduce high pressure to low, but change the intermittent arterial pulsations into a continuous and uniform capillary flow.

Endocrine causes

Pituitary

Persistent essential hypertension in the absence of renal involvement is constant in cases of basophilic adenoma of the pituitary body. Whether this is brought about by disturbance of interaction with other glands, or by excessive secretion and circulation of the pressor principle of the posterior lobe, as advanced by Cushing, is not yet decided.

Adrenals

The balance of evidence is against essential hypertension being due to an excess of adrenaline, the very active pressor principle secreted by the adrenal medulla, in the circulating blood. The case is otherwise, however, with tumours of the adrenal gland, either cortical (hypernephromas) or medullary (phaeochromocytomas). Such instances are rare, persistent hypertension appearing to be associated with tumours of the cortex, and paroxysmal hypertension, tending to become continuous, with those of the medulla. The so-called Grawitz tumours or renal hypernephromas are derived not from adrenal rests but from the renal tubules, and in these hypertension is not necessarily present.

Thyroid

Hyperthyroidism in younger patients is not associated with hypertension. This is more common in middle life, when true hypertension and thyrotoxicosis are combined, the suggestion being that essential hypertension, which occurs only in later life, is manifested then by those who are constitutionally disposed thereto.

Ovaries

The natural or artificially induced menopause may be attended or followed in a small proportion of cases by true hypertension. Far more frequently the menopause is marked by wide fluctuations of arterial pressure, probably in direct association with the disturbances in vasomotor regulation and lack of ovarian secretion common to cessation of the periods, and evidenced by flushing.

Fibromyomas of uterus

Uterine fibroids and other abnormalities of the reproductive organs in women are not infrequently associated with arterial pressures above the average, in certain instances combined with cardiac symptoms.

It is possible that in all the above the endocrine gland primarily involved does not suffer alone, but that others of the endocrine chain are also implicated in the lack of balance.

Toxaemia

The one certain toxic cause is lead poisoning. Other alleged causes, such as syphilis, previous infections, and the use of tobacco and alcohol, have not been proved to exert any influence in raising blood-pressure, nor have allergic disorders. The influence of autotoxaemia from the respiratory tract, from focal sepsis, and from the intestines is difficult to determine. Pressor amines are absorbed in the course of bacterial putrefaction of protein, and it is thought by many that they are instrumental in promoting elevation of blood-pressure, but the matter is still open to question.

Hypertonia

For elevation of pressure to take place hypertonia, or increase of tone of the muscle elements in the walls of the arterioles, must necessarily be widespread. Vasoconstriction of local areas, such as those of the kidney or extremities, is insufficient to bring about this result, the only possible exception being the large splanchnic area. That active arteriolar constriction precedes the onset of oedema and of retinal haemorrhage can readily be shown in cases of toxaemia of pregnancy. From this and other evidence it is clear that spastic constriction of the arterioles is the dominant factor in the production not only of high blood-pressure itself but of many of its symptoms and complications.

No stimulus due to cold, nor any single chemical substance such as adrenaline circulating in the blood, has yet been proved to bear any causal relation to raised blood-pressure.

Metabolic factors

As regards diet, a high protein intake, even continued over long periods of time, contrary to popular opinion, has no effect in augmenting blood-pressure or in promoting damage to the kidneys. Moreover, a low protein diet succeeds only in causing malnutrition without reducing blood-pressure. It is of interest that high blood-pressures are not infrequent in vegetarians, and that the incidence is not high in Eskimos and Arctic explorers living for years or months on an exclusively meat diet. The hypothesis is tempting that all hypertension begins as an alteration of the body metabolism, possibly as an attempt on the part of the organism to maintain the blood chemistry within normal limits. On the other hand, no characteristic metabolic abnormality has been found in high blood-pressure cases, nor for the most part has the basal metabolism undergone any notable elevation, being commonly within the limits of normality.

(*b*) *Pathology and Pathogeny*

Effects on the cardio-vascular system

In all varieties of hypertension, anatomical changes in the shape of cardiac hypertrophy and arteriolosclerosis can be correlated with the presence of protracted high blood-pressure. Cardiac hypertrophy due to this cause or to chronic glomerulo-nephritis at first involves only the myocardium of the left ventricle. Dilatation follows later in conjunction with hypertrophy and frequent dilatation of the other chambers. As a result of these changes the heart may become enormous (cor bovinum). Histologically each muscle cell is increased in size, but their number is not augmented. Long-continued hypertension may lead to the development of arteriosclerosis, though this sequence is by no means invariable. Arteriolosclerosis is, however, far more closely linked with persistent hypertension than is arteriosclerosis of the large vessels. The small vessels of the kidney are most often affected, and the spleen is the best indicator of the extent of damage. Hyaline degeneration of the intima is the initial change, and this is followed by a secondary fatty change, leading finally to occlusion of the lumen of the arteriole. Additionally there is a gradual atrophy of the muscular layer of the arterioles involved which becomes replaced by ischaemic fibrosis.

(*c*) *Relation to Constitution*

Constitutional high blood-pressure is met with in a small group of subjects who are otherwise free from symptoms and whose blood-pressures range only a little above the usually accepted standards of normality. Since for long periods of time these pressures remain at approximately constant levels—160 mm. Hg being the maximum for the systolic pressure, while the diastolic seldom exceeds 100 mm. Hg; figures below these being common—and, since they exhibit little or no variation when observed at intervals of six months or upwards, they should be taken as the normal for such individuals.

(*d*) *Relation to Cardiac Disease*

In many cases of high blood-pressure, even of long duration, it is astonishing to find how little the heart is affected. This is because the heart is involved solely as a result of increased load, assessable by the relative heights of the diastolic and differential pressures. In the majority of established cases, particularly when associated with thickening of arteries, the heart is beginning to labour under the strain, and shows signs of hypertrophy, rapid action and impaired response to effort.

Congestive cardiac failure

Later, dilatation ensues with signs of congestive failure—a persistent apical systolic murmur conducted to the left, tachycardia, feeble first sound, gallop rhythm, and finally a fall in the previously high pressure levels. These constitute a syndrome of circulatory insufficiency shown by slowing of the peripheral blood stream and venous stasis.

Anginal cardiac failure

A less frequent termination is by anginal heart failure, due to myocardial stretching or coronary disease, with substernal oppression or pain, sometimes radiating up the neck or down the arms, dyspnoea, and possibly pulmonary oedema.

(*e*) *Relation to Arterial Disease*

Arterio-sclerosis

Arteriosclerosis appears to arise from two main causes: (1) pathological changes, representing the essential nature of the malady; (2) morphological changes, the result of age, leading to distension, dilatation and eventual tortuosity and deformation of the arteries together with trophic disturbances followed by deposition of waste matter. Lange (1928) carefully studied cases of pure high blood-pressure in contrast to those of pure arteriosclerosis without rise of blood-pressure. He established the important distinction that, whereas in high blood-pressure there is vascular over-excitability due to sympathetic overstimulation of the musculature of the small peripheral vessels, in arteriosclerosis the vascular responses are sluggish and even weak.

Decrescent arterio-sclerosis

Senile arteriosclerosis, the decrescent form of Allbutt, is essentially an error of metabolism, possibly induced by progressive deviation of the acid-base equilibrium to the acid side, a characteristic of advancing years, leading to increasing difficulties in elimination of waste products.

Present-day views may be summarized as follows: (1) High blood-pressure may run its course independently of arteriosclerosis. (2) Arteriosclerosis is a clinical and pathological entity which runs its course in more than half the total number of cases independently of high blood-pressure. (3) There is a difference of opinion as to whether protracted high blood-pressure favours the development of arteriosclerosis.

Arteriolo-sclerosis

Arteriolosclerosis is far more closely correlated with protracted high blood-pressure than is arteriosclerosis. My own view is that intermittent high blood-pressure, in the form of angiospasm resulting from sympathetic overaction, however induced, tends to cause a state of hypertonia, and that hypertonia, maintained over increasingly long periods of time, gives rise to arteriolar constriction which leads eventually to actual thickening of the arteriolar musculature.

(*f*) *Relation to Renal Disease*

Nephrosis

Acute nephrosis is not associated with rise of blood-pressure except under conditions of anuria. The chronic form is associated with normal or low blood-pressures and with absence of cardiac hypertrophy. In amyloid nephrosis, rise of blood-pressure and hypertrophy of the heart are rare.

Acute nephritis

In acute glomerulo-nephritis both systolic and diastolic pressures may show slight increase, but more commonly this is transitory or absent.

Chronic nephritis

In chronic glomerulo-nephritis (chronic interstitial nephritis) high arterial pressure is the rule, but here also it may be transitory or absent. Moderate pressures may be met with, but often, especially in the less advanced stages, diastolic pressure is high, and is raised disproportionately to systolic pressure; a diastolic level of 130 mm. or more is not uncommon. As renal disease advances, both pressures may reach a high level, but not so high as in severe high blood-pressure. Both tend to persist and resist all attempts at reduction. Left ventricular hypertrophy usually occurs, progressing to dilatation, if uraemia or some other complication does not at first supervene.

The specific gravity of the urine in chronic interstitial nephritis is low (about 1010), with albumin and casts at first numerous but later few. Polyuria and nycturia are present. Haematuria is an early sign, diminishing later to microscopic evidences only.

Clinical symptoms are varied, often bringing the patient to those specializing in diseases of the eye, nose, stomach or nervous system rather than to the general physician. Such symptoms are headache, epistaxis (at times profuse and difficult to stop), retinal changes, gastro-intestinal disorders, cerebral haemorrhage especially in elderly subjects, uraemia and occasionally oedema.

4.–HIGH BLOOD-PRESSURE IN GENERAL

(1)—Course and Prognosis

Pure hypertension can only be studied before the onset of complications which materially alter its clinical character. Attempts have been made by investigation of apparently healthy schoolchildren and adolescents. The results show that elevation of blood-pressure begins as a transient functional phenomenon in those disposed by heredity or constitution to an over-responsive vasomotor system when exposed to psychical or physical stress. In later life it may be a reaction to the hurry and strain of modern civilisation in the form of a heightened excitability of the vasomotor centre.

From this point of view the course and prognosis are identical with these already given under 'Essential Hypertension'. The real differences lie in the onset of complications of the nature of arteriosclerosis and of chronic glomerulo-nephritis, which alter the clinical picture.

Prognosis

In prognosis, myocardial changes are of the greatest importance, by reason of their frequency, while the onset of Bright's disease materially increases the gravity. Impairment of renal function may be quick or slow, but with onset of uraemia the end is not far distant. Chronic glomerulo-nephritis accounts for approximately 8 per cent of deaths from uraemia, the mortality in general being greatest between the ages of forty and sixty years, from chronic myocardial insufficiency or coronary disease, chronic glomerulo-nephritis, or a combination of these. Cerebral haemorrhage occurs in about 25 per cent of cases, preceded by transient disturbances of function such as headache, epileptiform convulsions, aphasia, paralyses, blindness and coma, grouped under the heading of hypertensive encephalopathy.

Summary

An attitude of cautious optimism should be adopted in dealing with a patient who has raised blood-pressure. Notwithstanding the uncertainties and dangers to which he is exposed and the diminished expectation of life, the high pressure state as a whole, granted effective co-operation on the part of the patient, is often amenable to control, and the outlook therefore is much less gloomy than was formerly believed.

(2)—Diagnosis and Differential Diagnosis

Diagnosis of high blood-pressure states is made on the personal and family history of the patient, on a systematic investigation of the cardiovascular system, including the complete arterial pressure picture, and on ophthalmic examination.

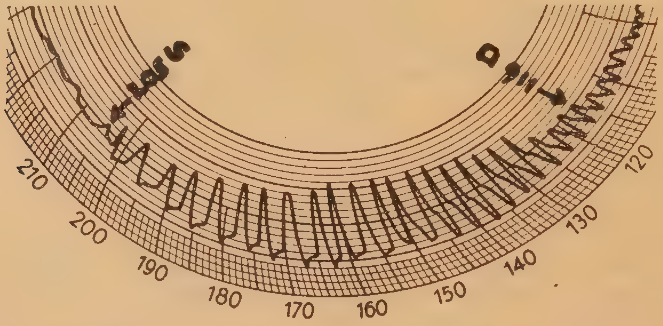

FIG. 78.—Tonoscillogram of high blood-pressure in a woman aged 46. Subarachnoid haemorrhage; arteriosclerosis. Systolic pressure, 205 mm. Hg; diastolic pressure, 116 mm.

Differential diagnosis of the type of high blood-pressure present is made by reference to (*a*) whether the pressures are transitory or persistent, labile or stable, (*b*) the presence or absence of cardiac hypertrophy, arterial or arteriolar sclerosis and their sequelae, and (*c*) the presence or absence of chronic glomerulo-nephritis which constitutes a sharp dividing line in assessing the gravity of the condition.

(3)—Effects of Long-continued High Blood-Pressure

On the cardiovascular system

The muscular tissues of the heart, arteries and arterioles become hypertrophied. For some time the hypertrophy involves solely the left ventricle; later the other chambers usually undergo hypertrophy and dilatation. The total size of the heart may thus become enormous (cor bovinum). Histologically, the hypertrophy is seen to be due to increase in bulk of the individual muscle cells, their numbers being unaffected. When dilatation supervenes on hypertrophy, interstitial fibrosis and cellular degenerative changes appear. A similar muscular hypertrophy of the media in the larger arteries is not infrequent, and arteriosclerosis of arterial vessels of all sizes is a common but not invariable finding.

Changes in the arterioles are associated far more closely with protracted high blood-pressure than are changes in the arteries. Arteriolosclerosis has a characteristic distribution in the internal organs, and involves chiefly the kidneys (in which it is severe and almost invariable), and the brain, retinae, pancreas, spleen and liver, not invariably and in lesser degrees. In the smallest arterioles the first histological change is sub-endothelial hyaline degeneration succeeded by fatty changes. The lumen becomes much narrowed and finally occluded. In the larger arterioles gradual atrophy of the media is followed by substitutional ischaemic fibrosis.

On the brain

'Hypertensive encephalopathy' is the term applied to transient disturbances—aphasia, paresis of one or more limbs, or blindness—which serve as warning signals of notable increase in blood-pressure or of small localized haemorrhages in the brain. Epileptiform convulsions, headache and vomiting are the most frequent prodromes which suggest the onset of either cerebral angiospasm or oedema. Fatal cerebral haemorrhage is probably the end-result of a long-standing arteriosclerotic narrowing and occlusion which cause areas of softening, thus depriving the cerebral vessels of some support. In cases in which previous softening is absent, the haemorrhage results from atheroma in conjunction with high blood-pressure.

On the kidneys

In the first stages of glomerulo-nephritis the changes are confined to the glomerular capillaries. As the disease becomes more chronic, the whole of the renal elements—glomeruli, tubules, vessels and interstitial connective tissues—are implicated. The changes are those of hyaline and fatty degeneration with replacement fibrosis.

(4)—Treatment

(*a*) *Preventive and Symptomatic*

In attempting to prevent high blood-pressure we are handicapped by insufficient knowledge of the cellular physiology which underlies the primary disorder of vasomotor function and adaptation.

Prevention of the symptoms

In the Great War psychopathic phenomena, grouped under the heading of shell shock, were found to be identical with the anxiety states, neurasthenias and hysterias of civil life, and it was realized that these manifestations were based on a constitutional and hereditary factor, which lay dormant until activated by environmental stresses and strains. It follows that prevention should begin as early as possible with endeavours to control those indefinite and numerous symptoms which may precede the onset of high blood-pressure and are of the nature of an hereditary vasoneurosis.

During the course of most cases symptoms closely linked with the nervous system are evident. It is now thought by most observers that psychic elements constitute an important and at times a dominant part in hastening or provoking a rise of blood-pressure in individuals susceptible by reason of inherent disposition. Such a conception affords a clue to prevention and early treatment by controlling the environment, occupation, attitude of mind, education and mode of life of the patient.

Environment

The environment should be adapted to the individual, both mental and physical welfare being considered. Emotional stress, anxiety and over-exertion should be avoided, and a quiet life in congenial surroundings is desirable. Occupations of steady routine are preferable to those involving anxiety or risk and should be seasoned by restful holidays.

A mode of life should be planned so as to promote regular and methodical habits with stated hours for meals, for rest, and for daily efficient evacuation of the bowels. Sexual excess, over-eating, over-smoking and heavy drinking must be avoided. There is no specific treatment. The main indications are to reduce the height of the blood-pressure while maintaining the efficiency of the heart.

Diet

The diet should be varied, balanced and moderate. Excess of fats and carbohydrates should be avoided as being likely to cause digestive troubles and to augment blood-pressure by inducing obesity. Animal protein, including all forms of meat, bacon and fish, should be diminished in accordance with the body-weight of the individual, bearing in mind that undernutrition may lower vitality and thus be injurious. More benefit accrues from lessening total food intake than from mere protein restriction. The diet should consist mainly of fresh milk, vegetables, eggs and fruit. Salt at table should be restricted. Water is the best fluid, taken on an empty stomach in moderate quantity an hour before meals and at bedtime. Should congestion of the liver or uric acid retention be present, Vichy water, the most alkaline of all table waters, is very useful. Other drinks should be taken sparingly. China tea is preferable to Indian blends and should be freshly infused and taken weak. Coffee containing a reduced proportion of caffeine should be substituted for ordinary coffee. In general, alcohol should be avoided, but very small quantities well diluted may be taken with meals. For the plethoric and obese a day of fasting once a week is frequently of great help in reducing blood-pressure and aiding elimination of waste products.

Exercise

Regular daily exercise, on foot, on horseback, or in the form of games and sports, is beneficial, but fatigue must be avoided and efforts should never be made to vie with the healthy in tests of endurance, or to take part in sports that involve sudden or prolonged strain.

Rest

Sufficient sleep is essential, the exact amount depending on the individual, but a minimum of eight hours in bed should be enjoined. Recumbent rest after the midday meal is advantageous for those of excitable, emotional or apprehensive temperament. Finally, the key-note in the avoidance as well as in the control of high blood-pressure should be moderation in all things.

(*b*) *General Treatment*

The aetiology and pathology of high blood-pressure not being fully understood, treatment is largely based on experience and observation. It is probable that if high blood-pressure can be controlled early, i.e. while still in the functional stage, it will not give rise to structural vascular changes with their harmful results; and that in the absence of complications reduction of pressure is often accompanied by amelioration of symptoms. On the other hand, there are some cases in which no treatment succeeds in reducing high pressures. Although on the whole the expectation of life is lessened, owing to the possibility of a sudden fatal termination or the probability of a more gradual deterioration, much can be done. Hence, in dealing with the individual an attitude of tempered optimism should be adopted, and the patient should be advised to persevere but not to expect immediate or dramatic improvement. A hopeful frame of mind, combined with alleviation of the more serious symptoms, not only reassures the patient but tends to arrest the progress of the disease. Anxiety should be allayed, for the fear of blood-pressure is frequently more deleterious than the high pressure itself. More detailed treatment may conveniently be discussed in relation to the three main clinical groups into which the condition falls—namely, the latent, cardiovascular and renal.

Cases without symptoms are by no means uncommon, and usually require no definite treatment. Misguided attempts to depress the elevated pressures serve no useful purpose, and merely make the patient miserable. It is better not to let the patient know the actual height of the pressures recorded; but, if he insists, to explain that the heightened pressure represents an effort of the body to compensate for some circulatory maladjustment which may be only temporary. Suitable information may be given to the relatives with instructions that this must not be communicated to the patient.

Management of early stages

The preventive measures outlined in the preceding section are equally applicable to the management of the early stages of high blood-pressure with symptoms. To discover the condition as early as possible is of the greatest service to the patient. While recovery is still possible, much can be done, by regulation of diet, rest and exercise, to improve the general health and to correct errors of metabolism. Psychical influences which promote and maintain elevation of pressure should receive adequate attention, and any lack of endocrine balance discovered, particularly pituitary, thyroidal, adrenal or gonadal, should be rectified. Disturbing influences in daily life, such as domestic irritation or occupational anxiety, should be as far as possible removed. Unsuitable or excessive diet should be adjusted and excess of alcohol or tobacco discouraged. Longer hours of rest often do wonders. Reassurance, strengthened by direct suggestion, persuasion and re-education, also if necessary by sedatives and hypnotics, is of distinct value, particularly for women at the time of the menopause.

With increasing pressure levels, three pathological stages are entered upon which indicate transition from functional to organic forms. These are successively: (1) hypertonia of the muscular coats of arterioles, sometimes of capillaries and veins, (2) progressive hypertrophy of the muscular tissues of the cardiovascular system, and (3) vascular narrowing due to advancing fibrosis. Only the first of these stages is remediable.

Treatment of the cardio-arterio-sclerotic group

In hypertensive cases cardiac failure is the chief cause of death, and a careful watch should therefore be kept upon the state of the heart. Indications for treatment are afforded by signs and symptoms. The first and most valuable remedy is rest in bed, because the heart muscle, if given sufficient chance, has great capacity for recovery. Especially is this so when the heart muscle has suffered defeat as a result of labouring for long against excessive arterial pressures. Never, however, should drastic attempts be made by large doses of powerful vasodilators to cause a sudden drop in an unduly high pressure, for grave and sometimes irreparable harm may be done.

Digitalis is the most valuable drug, and when cardiac insufficiency arises from any cause may safely be given, for under its influence systolic and diastolic pressures are often lowered and differential pressure is increased. If the pulse-rate can be reduced to between 60 and 66, digitalis is doing good. When, however, fibroid myocarditis is suspected, digitalis should be used with caution.

Of congestive heart failure

In congestive heart failure, blood-pressure is frequently reduced by (1) cardiac tonics and diuretics, such as digitalis, theobromine and sodium salicylate, calcium diuretin, or euphyllin; (2) depletives, such as mercurials by mouth, salines, leeches and venesection; (3) inhalation of oxygen for dyspnoea. For oedema salyrgan may be given if the kidneys are sound.

For the anginal form of cardiac failure, iodine, bromides, hot drinks with diffusible stimulants, and counter-irritants have their uses. For severe cases atropine or morphine may be necessary.

Of arterio-sclerosis

Treatment in arteriosclerosis must needs be largely symptomatic. Warning should be given, as in coronary disease, to avoid sudden exertion and violent emotion. General hygiene, moderate diet, and elimination by calomel and salines bi-weekly are useful; and for arrhythmia and premature ventricular contractions the compound mercury and digitalis pill is of great service.

Of renal disease

To maintain glomerular filtration and adequate excretion of urine in a kidney with already damaged glomeruli, a greater head of blood-pressure is requisite than under ordinary circumstances. Hence, it is well to bear in mind the possibility that the elevation of blood-pressure so induced may be necessary and advantageous in compensating for a lessened area of filtration.

Of acute nephritis

In acute nephritis, the chief indications are to lighten the excretory task of the inflamed kidneys by rest in bed, fasting for two or three days, tepid baths, light massage, moderate purgation with magnesium sulphate and removal of infective foci.

Of chronic nephritis

In chronic glomerulo-nephritis, when evidences of renal insufficiency arise, it is advisable to adjust the diet according to the capacity of the kidney to excrete urine of a specific gravity of 1,020 or over. If the specific gravity is below this or the blood urea is high, protein should be restricted to about 2 ounces daily, or less if there is much impairment of concentration. Salt intake should be restricted, even in the absence of oedema, by taking no table salt with meals. It is wise to restrict the fluid intake, and diuretics are of no avail when the kidneys are much damaged. Severe headache may be relieved by venesection or analgesics. Cathartics should be given if the bowels are not opened normally. Daily warm baths are to be preferred to strong diaphoretic measures. For ambulant cases a quiet life, an equable climate, a dry house, warm clothing, a light and unstimulating diet and avoidance of work and worry are beneficial.

Of uraemia

In uraemia, saline cathartics, pilocarpine and warm baths for half an hour followed by hot drinks and bed between hot blankets help to ward off coma.

Physiotherapy

Physical measures of control include rest, exercise, deep breathing exercises, resistance exercises, muscular relaxation, light massage, high frequency, diathermy, X-rays, ultra-violet radiation, hydro- and balneotherapy, lumbar puncture, venesection and fasting.

Psychotherapy

The first step towards psychical control is to inspire confidence and to allay the patient's fears, especially of blood-pressure itself. Reassurance, if accepted, is of itself a valuable therapeutic measure. A sympathetic talk may succeed in bringing to light half-conscious anxieties and worries that the patient keeps to himself, but a special knowledge of psychotherapy is required to discover and treat deeper-lying psychological disturbances. Mental repose and physical relaxation with elimination of sources of perturbation should be the aim.

Drug therapy

In treatment drugs play but a secondary part. They are not always necessary, but have their uses in controlling the functional stages of hyperpiesia, in altering underlying causes, in supporting other remedial measures and in dealing with complications. A nihilistic attitude towards drugs does not tally with my own experience. Often, however, they are given in too large doses. In the presence of irksome or dangerous symptoms, rest in bed for a week to a fortnight proves of much service in aiding medicinal therapy. Calomel, ½ to 1 grain, twice weekly at bedtime, followed by a teaspoonful of magnesium and sodium sulphates in equal parts on the morning after, are useful in promoting elimination by the bowel in plethoric and obese subjects; but should not become a regular habit. Palpitation and restlessness are helped by ammonium bromide 10 grains, and aromatic spirits of ammonia 10 minims, in a mixture with tincture of sumbul 10 minims, or compound tincture of cardamoms

½ to 1 drachm. Vasodilatation is aided by small doses of iodine, iodides, bromides and bismuth subnitrate, the effects being gradual but lasting. In the absence of renal impairment, pure potassium sulphocyanate, 2½ grains in aqueous solution, thrice daily after meals for the first week, but after that in reduced dosage, causes lowering of blood-pressure and abatement of symptoms in about 35 per cent of functional cases. The quantities, however, must be carefully watched, as the drug is cumulative and sometimes causes toxic symptoms. In anxious and irritable patients sedatives are of the greatest benefit, and in the larger doses often restore normal sleep. Such sedatives are chloral hydrate and potassium bromide (10 to 20 grains of each), which are useful also in relieving pressure headaches; phenobarbitone (luminal), 1 to 3 grains daily in divided doses or ½ to 1 grain at bedtime, which may with advantage be combined with sodium biborate 3 to 5 grains to enhance the sedative effect.

In old people opium, when the kidneys are sound, controls nervous symptoms and induces rest. Clinical experience disposes one to think that intestinal toxaemia is a factor in the production of hyperpiesia although there is lack of laboratory confirmation. High pressures in cases of gastro-intestinal stasis and catarrhal conditions of the bowel appear to be relieved by methods of detoxication, such as Plombières lavage or rectal injections of potassium permanganate, 1 grain to 1 pint of water daily for a fortnight, the solution being then gradually weakened.

Organo-therapy

Clinical experience does not bear out many of the claims which have been made for the extended use of certain hormones. During the past few years pancreatic extracts have been advocated as producing vasodilator and depressor effects. Of these, Frey's 'circulatory hormone' (padutin), given intramuscularly in doses of 1 unit twice daily for three days, then 2 units twice daily, appears to exert a temporary effect in some cases of angiospastic hypertension, but lasting effects are less certain. Vagotonine is stated to augment vagal and secondarily to diminish sympathetic tonus, thus acting as a circulatory regulator but not as a depressor (Santenoise). A trial injection of 0·02 gram is given subcutaneously, and if there is no definite decline of pressure within two hours, the regulator mechanism is regarded as not being at fault. If the pressure falls, the remedy may be continued. Angioxyl is another pancreatic extract which is given subcutaneously in daily doses of 2 c.c. None of these, however, are as useful as their inventors originally claimed. Acetylcholine subcutaneously in daily dosage of 0·1 to 0·2 gram resembles vagotonine in action, and is at times helpful.

Ovarian extracts

Ovarian extracts are often given in climacteric disturbances, but usually without reducing blood-pressure. Preparations of oestrin are more promising in abating some of the unpleasant symptoms common to this time of life.

Thyroid extracts

Apart from their influence on co-existent hypothyroidism and obesity, thyroid extracts have little or no effect on the blood-pressure, although in some cases they have been beneficial.

Liver extracts

Liver extracts may cause a temporary reduction in blood-pressure, but in my experience have no lasting effect.

Vasodilators

The members of the nitrite group of vasodilators have a family likeness differing only in the rapidity, amount and duration of their effects. They should be used only in emergencies, since in action they are evanescent. Amyl nitrite, 3 to 5 minims, is commonly inhaled from capsules to ward off anginal pain, threatened cerebral haemorrhage or heart failure from excessively high blood-pressure. Erythrol nitrate has a slower action in ¼ grain doses by mouth thrice daily and may be used in combination with diuretics or diaphoretics to lessen the circulatory load.

Alkalis and carminatives

Alkaline and stomachic carminative mixtures are useful as adjuvants in keeping down persistent high blood-pressure associated with gastro-intestinal disturbances.

5.–LOW BLOOD-PRESSURE

Physiological aspects

171.] Low blood-pressure expresses low vitality. It may be hereditary, constitutional, familial or acquired. The patient exists in a depressed state in which there is a poor and inadequate response both to normal and abnormal stimuli. Errors of assimilation constitute the dominant factor, contrasting with inadequacy of elimination in hypertension.

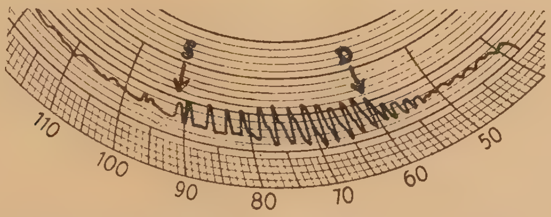

FIG. 79.—Tonoscillogram of low blood-pressure in a man aged 50. Systolic pressure, 91 mm. Hg; diastolic pressure, 60 mm.

Systolic and diastolic pressures

For practical purposes the systolic limit may be taken as 110 mm. for adult males and 105 mm. for females, estimated at least two hours after a meal. The corresponding diastolic limit is normally 66 for males and 62 for females, but is subject to much greater variation. The lowest levels are associated with disorders of internal secretion, and the highest with chronic glomerulo-nephritis. In feeble subjects the sound usually taken as the index of diastolic pressure may be inaudible. The common range is from 110 to 90 mm. for systolic pressure, and from 80 to 60 for diastolic pressure.

The low arterial pressure state comprises all conditions in which blood-pressure is absolutely low—i.e. not relatively low consequent upon a previous high blood-pressure state. It includes such conditions whether they are physiological or pathological, temporary or permanent.

Occurrence It is a symptom of many diverse conditions. Physiologically it is met with in quiet sleep, fatigue and during menstruation. It tends to become permanent in placid temperaments, routine occupations, and warm climates, in athletes and in uncomplicated old age. Pathologically it is met with in collapse and shock; in toxaemias, intoxications, and nearly all the acute specific infections; in chronic states attended by wasting, particularly in advanced pulmonary tuberculosis; in the anaemias and myasthenia gravis; in chronic arthritis; and as a terminal event.

Pathology When low blood-pressure is a symptom of disease, it may originate from one of several underlying causes, or from a combination of these. Lack of endocrine correlation, especially pituitary, thyroid or adrenal deficiency, is a potent cause. The arteriolar tone is diminished and the compensatory reaction of the heart to this condition is inadequate.

Clinical picture The main clinical feature of all forms of low blood-pressure is a disinclination for physical and mental exertion. The chief manifestations are pallor, flabbiness, and circulatory inertia leading to congestion of the extremities. There are feelings of apprehension and incapacity, slow cerebration and impaired memory, depression, insomnia, headache, dizziness, faintness and gastro-intestinal disorders.

Treatment Many subjects who are apparently fit, and have few or no symptoms, need no treatment. In others treatment is ineffective, and in the remainder it should be directed to conserving energy, stimulating vitality and redressing the disturbed metabolic balance. For bad cases rest in bed is essential. Exercise should be increased gradually in proportion to the patient's capacity and freedom from discomfort, but should never be strenuous or prolonged. Diet should be ample, balanced, nourishing and easily assimilable. Holidays with gradual acclimatization to sunshine are beneficial. Physiotherapy in various forms is often useful. Whole gland pituitary substance (with the addition of small doses of thyroid in selected cases) is of great value, as is ephedrine or synthetic ephedrine in ¼ grain doses. For circulatory and nervous disorders cardiazol may be recommended; for fatigue, adrenaline; for morning depression and headache, caffeine citrate; for dizziness, quinine hydrobromide; for broken sleep, sedormid or somnifaine are preferable to the more toxic hypnotic drugs; for vagotonic symptoms in general, atropine. Salicylates and acetylsalicylic acid (aspirin) hardly ever suit patients with low blood-pressure and reduce vitality by aggravating any existing depression.

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BLOOD TRANSFUSION

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Reference may also be made to the following titles:

ANAEMIA BLOOD EXAMINATION

1.–GENERAL EFFECTS OF TRANSFUSION

172.] Blood transfusion as a therapeutic procedure consists of the withdrawal of blood from the vein of a healthy human donor and its administration intravenously to the patient. Many years ago it was shown that if the blood of one species of animal was run into the circulation of another the injected corpuscles were quickly destroyed and the recipient animal showed more or less marked constitutional reaction. Early attempts at transfusion from one human being to another were accompanied by similar, and sometimes fatal, reactions. Landsteiner, by demonstrating the existence of 'blood groups' in human beings provided the explanation and showed that reactions could be avoided if the patient were transfused from a donor whose blood had been previously shown to be suitable. Once the technique of satisfactorily proving the 'compatibility' of bloods had been established, the therapeutic uses of transfusion extended steadily.

Haemopoietic stimulus

At first transfusion was used almost exclusively in severe post-haemorrhagic anaemia to replace blood lost. It was then found that it did more than this. The added blood increased the blood volume, the rate of blood-flow and the blood-pressure, and improved the pulse. The immediate increase in the haemoglobin percentage and the red-cell count was followed by a further rise reaching a maximum about twenty-four hours after the transfusion. Clearly the improvement could not be attributed to the added blood alone. A stimulation of the patient's own blood-forming tissues must have occurred, further evidence of this being a secondary rise in both the white-cell and platelet counts.

2.–SELECTION OF DONORS

Donors must be vigorous and healthy in every respect, particular requirements being a negative Wassermann reaction, a normal blood count, entire absence of tuberculous or allergic history, and no blood infection such as malaria or fevers during the incubation period.

Compatibility: matching in emergency

If dangerous reactions are to be avoided, it is necessary that the donor's cells are not agglutinated or destroyed by the patient's serum. In emergency, therefore, with lack of laboratory facilities, it will suffice to collect a few drops of blood from the patient with some form of Widal pipette from a finger prick. The blood is allowed to clot and a drop of the serum is placed on a clean glass slide. Into this is stirred a small drop of the donor's blood also obtained by finger prick, and the mixture observed by naked eye or hand lens for about twenty minutes. If the donor's cells remain unagglutinated and floating as an even suspension in the patient's serum, the main requirement in matching is fulfilled. Perfect compatibility is assured if the above test is repeated but using a mixture of donor's serum and patient's cells, i.e. reversing the sources of the serum and cells. If both tests are satisfactory, the two bloods are said to 'cross-match' perfectly.

It might seem therefore that determination of blood groups as a routine preliminary to transfusion is unnecessary. But two circumstances make it always advisable, when a transfusion may be required and if laboratory assistance is at hand, to test the blood groups of the patient and any potential donors at the earliest opportunity. First, the percentage incidence of the four blood groups are against the chances that any two bloods taken at random will be compatible. It is unsafe to assume that close relations, e.g. father and child, or brother and sister, are necessarily of the same group; often they are, but just as often they are not. Secondly, if request is made for a donor to one of the Blood Transfusion Services it is essential that the recipient's blood group be stated, so that a donor of appropriate group may be sent.

Organized Donor Services

The organized donor services usually consist entirely of volunteers who receive from the organization nothing but their travelling expenses, and frequently prefer to remain anonymous. To hospitals and patients of the poorer classes no charge whatever is made, but it is customary for private patients to make to the service a subscription commensurate with their means.

Care of Donors

The work carried out by these services does not consist of organization only. Apart from the list of donors and their telephone numbers, accurate records of their transfusion and health histories are kept. The operator is always asked to send details of the operation and its result. Arrangements are also made for the original grouping of the donors and for any subsequent clinical or laboratory examinations that may be necessary. It is usual not to allow donors to act more frequently than once a month. Volunteers are accepted by the services only when their veins are reasonably good, so that it may not be necessary to cut down on their veins; indeed in some services cutting down is strictly forbidden. Following collection of blood, the donors should be allowed to rest, lying down, for about twenty minutes, and meanwhile they should receive some fluid in the form of tea or coffee and a certain amount of carbohydrate. If this simple precaution is taken, healthy donors will feel no after-effects. In women donors it is particularly important to avoid unnecessary damage to their veins or the production of unsightly scars by cutting down.

3.–DETERMINATION OF BLOOD GROUPS

(1)—Classification and Terminology

Moss grouping: Janský grouping: international terminology

To remove uncertainty as to the meaning of the various classifications now in use, it must be explained that in 1907 Janský made the first classification, using the arbitrary terms Groups I, II, III and IV. But Janský's work was not widely known and in 1909 Moss published a classification into four groups, using the same numerals, and his description has been very generally accepted in America and Europe. Unfortunately the arrangements proposed by these two workers differ in that, while the Moss Groups II and III correspond with the Janský Groups II and III, Groups I and IV are transposed. Their exact relationship is shown below. More recently an international terminology has been proposed based upon the presence or absence of the two possible agglutinogens A and B within the red cells. This would be an entirely satisfactory classification, but, the Moss terminology being now well established and in general use by the Blood Transfusion Service authorities, the practitioner is advised to use it still and it is placed first in the comparative table given. To avoid all possible error the name of the classification should be included in the report thus: Group II (Moss), and misunderstanding avoided.

MOSS	JANSKÝ	INTERNATIONAL
I	IV	AB
II	II	A
III	III	B
IV	I	O

Relationship of the four groups

The biological explanation of the four groups is based upon the presence in human red cells of two different substances here described as agglutinogens A and B. It is obvious that agglutinogen and corresponding agglutinin cannot both be present in the blood of one individual or his serum would agglutinate his own corpuscles; but it is found that any individual whose corpuscles do not contain the A agglutinogen will have A agglutinin in his serum; similarly everyone's blood contains either B agglutinogen in the cells or B agglutinin in the serum. Group IV corpuscles, which contain neither agglutinogen, are not agglutinated by any human serum, and can safely be given to a member of any blood group—universal donor. Group IV serum contains both A and B agglutinin, and a Group IV patient can therefore receive only corpuscles containing neither agglutinogen, i.e. Group IV corpuscles. Group I serum contains neither agglutinin, and this group can therefore receive any type of corpuscles—universal recipient. On the other hand, Group I corpuscles with both A and B agglutinogen, can only be given to patients with no agglutinins in their serum, i.e. Group I patients.

Universal donor

Universal recipient

In summary the position is as follows:

Group I (Moss) can give to Group I (Moss) alone.
Group II (Moss) ,, ,, Groups I and II (Moss)
Group III (Moss) ,, ,, Groups I and III (Moss)
Group IV (Moss) is the 'universal donor'.

The term universal donor has been placed in inverted commas because, although in almost all instances the name is justified, yet one meets on rare occasions Group IV bloods which do not cross-match perfectly with each other, and one or two cases have been recorded in which, a Group IV donor having been used for a patient of another group, the *donor's serum* has been of such high agglutinating titre towards the *patient's cells* that severe reaction has been produced. Careful cross-matching of the bloods will draw attention to these rare possibilities, but the point will be referred to again in the next section.

Medico-Legal Significance of Blood Groups

The percentage incidence of the blood groups in Europeans is as follows:

Group I, 3 per cent; II, 43 per cent; III, 7 per cent; IV, 47 per cent.

Inheritance of blood groups

The agglutinogens A and B are inherited as Mendelian dominants, and it is therefore impossible for an agglutinogen to be present in a child unless it was present in one of the parents. This fact may be of value in cases of disputed paternity, e.g. if the mother belongs to Group IV (O) and the child to Group II (A) the A agglutinogen must be inherited from the father, who therefore must belong to either Group I (AB) or to Group II (A). It is clearly impossible to prove paternity by this method—in the instance given any man belonging to Groups I or II might be the father—but it may be possible to prove non-paternity, although the chance of doing so averages only 1 in 6. Wiener has drawn up the following table showing the possibilities in inheritance of blood groups, and no exceptions to this table have been established:

BLOOD GROUPS OF PARENTS	POSSIBLE BLOOD GROUPS OF CHILDREN	IMPOSSIBLE BLOOD GROUPS OF CHILDREN
O × O	O	A, B, AB
O × A	O, A	B, AB
O × B	O, B	A, AB
A × A	O, A	B, AB
A × B	O, A, B, AB	None
B × B	O, B	A, AB
O × AB	A, B	O, AB
A × AB	A, B, AB	O
B × AB	A, B, AB	O
AB × AB	A, B, AB	O

Agglutinogens M and N

Landsteiner and Levine have recently established the existence in human red cells of two additional agglutinogens, M and N, which are also inherited as Mendelian dominants and which are quite independent of the A and B agglutinogens. They may furnish evidence of the sam value in proof of non-paternity, and by the use of all four agglutinogens the chance of establishing non-paternity is increased to 1 in 3. Agglutinins corresponding to M and N agglutinogens never occur in human sera, and the existence of M and N factors can only be demonstrated by the use of serum of immunized rabbits. They do not affect ordinary grouping tests, and are of no importance in blood transfusion.

Blood groups as evidence of paternity

Whenever one is faced with the question of proving parentage, it should be emphasized that this cannot be done by blood grouping. All that can be shown is that a particular parentage is possible or impossible. Often the latter is just what the inquirer does not want to prove, so the appropriate warning should be given. Cells obtained from shed human blood or washed out of stains with normal saline can be 'grouped' in the same way as those from fresh blood. But here again the most valuable results are of the negative type—that is to say, the blood, by being of the wrong group, may be shown to have come from some person other than the one suspected. At present the results of blood-group tests are not accepted as conclusive evidence of paternity in English courts of law, although they are now recognized for this purpose in several other countries.

(2)—Technique of Grouping using the Moss Classification

The technique of 'grouping' using the Moss classification is simple. Fresh specimens of high-titre sera of Groups II and III are required and can be obtained from institutions handling serological products.

Agglutination of standard sera

Small drops of each are placed on a clean glass slide about one inch apart and with each drop is mixed a little blood from the person to be tested, obtained by oxalating some blood from a finger prick. These are watched for twenty minutes to see whether the cells are agglutinated in either of them. The results are read as shown below, + indicating agglutination and 0 its absence.

PATIENT'S SERUM PLUS GROUP II SERUM (MOSS)	PATIENT'S SERUM PLUS GROUP III SERUM (MOSS)	RESULT
+	+	Group I (Moss)
0	+	Group II (Moss)
+	0	Group III (Moss)
0	0	Group IV (Moss)

Errors due to old sera

This simple test is subject to one serious risk of fallacy. The standard sera must be fresh. The laboratory stores the ampoules in the freezing chamber to preserve the agglutinins and they are tested at intervals. If they are allowed to stand at room temperature for even short periods the agglutinins rapidly weaken and disappear. Then if a grouping test be made, whatever the cells examined, no agglutination will occur in either drop of serum and the result will be read as Group IV. As this is the universal donor group, the risk is obvious; the patient may be transfused with a grossly incompatible blood. It is true that cross matching should obviate this sort of error, but several fatalities are on record which almost certainly arose in this way.

The patient and any relatives who volunteer should be grouped at the earliest opportunity. If all the relatives prove incompatible a donor of the same group is obtained from the Transfusion Service.

In recent years the demand for Group IV (universal) donors has risen disproportionately. If the trouble of grouping patients is habitually avoided by always asking for Group IV donors, the call upon volunteers of this group will be excessive and, as has already happened, the donor organizations will find it increasingly difficult to provide them when the patient is Group IV and a Group IV donor is essential.

Cross-matching

Finally it is strongly advisable to cross-match the bloods of patients and donor even although they have been shown to belong to compatible groups. This acts as a safeguard against any error in grouping patient or donor; against the instances of aberrant groups occasionally recorded; and against the very rare anomalies mentioned in connexion with 'universal donors'. Ideally, a patient should always be transfused from a perfectly matching donor of the same group as himself. The risk of reactions is then reduced to an absolute minimum.

4.–TECHNIQUE OF TRANSFUSION

(1)—The Three Methods

Quantity

The total quantity of blood customarily transfused at one time varies from 400 to 700 c.c., the limits being set by the amount which can justifiably be removed from one donor rather than the volume which the patient may safely receive. The larger volumes are required when the blood volume and blood-pressure of the patient have to be restored quickly. Much smaller quantities may be effective stimuli to the blood-forming tissues. In adults a useful guide is to transfuse 3 c.c. for every pound of body-weight, and in children, 5 to 10 c.c. per pound of body-weight.

Whole blood without anti-coagulant

Blood may be transfused as whole blood without anticoagulant, defibrinated blood or citrated blood. In this country whole blood without anticoagulant is now seldom used. It necessitates the patient and donor being brought close together—an undesirable arrangement. Great speed is required otherwise the blood may clot in the apparatus. The method can be efficient only in very experienced hands. The element of speed also requires that in many patients, in order to obtain a rapid flow, the veins must be cut down upon and in any circumstances whole blood transfusion calls for the presence of one or more skilled assistants. Finally it may be emphasized that there is considerable doubt whether the advantages claimed, on theoretical grounds, for the therapeutic superiority of whole blood without anticoagulant really exist. At the present time it is generally considered that, in spite of the many past attempts to perfect a method, all forms of vessel to vessel transfusion of whole blood present so many technical difficulties that their use should never be advocated.

Subcutaneous injections of whole blood

There are, however, two occasions when the injection of whole blood, subcutaneously, not intravenously, may still be used with advantage. The first is the use of small (5 to 10 c.c.) injections of blood withdrawn by needle and syringe from the donor's veins and immediately injected subcutaneously or intramuscularly into the patient's buttock, to act as a coagulant when the patient shows a tendency to excessive bleeding. The second is the injection of whole blood in the same way into anaemic patients as a haemopoietic stimulus when they have failed to respond to other forms of therapy. With the intramuscular or subcutaneous injections it is not necessary to group the bloods.

Defibrinated blood

For defibrination the blood as it is withdrawn is stirred continuously with some form of bent glass rod to which the fibrin adheres, forming a brownish mass which can be removed bodily upon the rod. After defibrination the blood must always be filtered to remove any small fibrin threads which still remain after the main mass is withdrawn and this complicates technique.

Citrated blood

The method now usually favoured in British hospital practice is the use of citrated blood, other methods being seldom used, although defibrination still has its supporters. In the citrate methods just enough 3 per cent sterile sodium citrate is added to freshly drawn blood to prevent clotting. Excess of citrate is said to increase the fragility of the red cells, to reduce the activity of the white cells, and to destroy some of the vital elements of the serum, but results show that if the citrate be added gradually and not in excess these disadvantages become negligible. The citrate method has therefore been widely adopted for general and routine purposes. It is convenient also, that sterile citrated blood will keep for a considerable time and may be transported long distances before being used for transfusion. Filtration is not essential after citration.

(2)—Apparatus and Procedure

(*a*) *Simple Technique in Emergency*

There are so many types of transfusion apparatus available that to describe them all is impossible. A satisfactory apparatus should be compact, easily sterilized, and simple in the sense that during the operation the least possible dismantling and re-connexion of parts are required; the blood should not be allowed to cool and at no time should it come in contact with a gross excess of citrate.

The simplest arrangement is as follows: the blood is withdrawn from the donor by means of a medium-sized needle connected to a straight rubber tube which dips into a sterile graduated bottle of about 800 c.c. capacity (Fig. 80). A certain amount of citrate, say 25 to 50 c.c., is first placed in the bottle, which, as the blood runs in, is kept moving to mix the contents thoroughly. As the blood collects, more citrate is added, keeping the proportions at about 1 c.c. of 3 per cent citrate to every 5 c.c. of blood. When about 500 c.c. of blood have run into the bottle the needle is removed, a dressing placed on the donor's arm and the bottle of citrated blood stood in a bowl of warm water at about 40° C. The citrated blood can now be run into the patient's vein by any simple gravity method using a tube and funnel as indicated in Fig. 81.

The objections to this method are that it is difficult or impossible to avoid some cooling of the blood, it is not strictly aseptic as the blood may be exposed to contamination from the air and other sources, and also the blood-flow from the donor and into the patient is not under the best possible control. Nevertheless it can be made to work well and is the obvious choice in an emergency.

(*b*) *Permanent Hospital Installation*

When transfusions are of frequent occurrence more satisfactory methods can be devised, which not only fulfil all the requirements mentioned above but also reduce the incidence of reactions and the necessity for puncturing veins more than once or for cutting down on them. Such a method is described below.

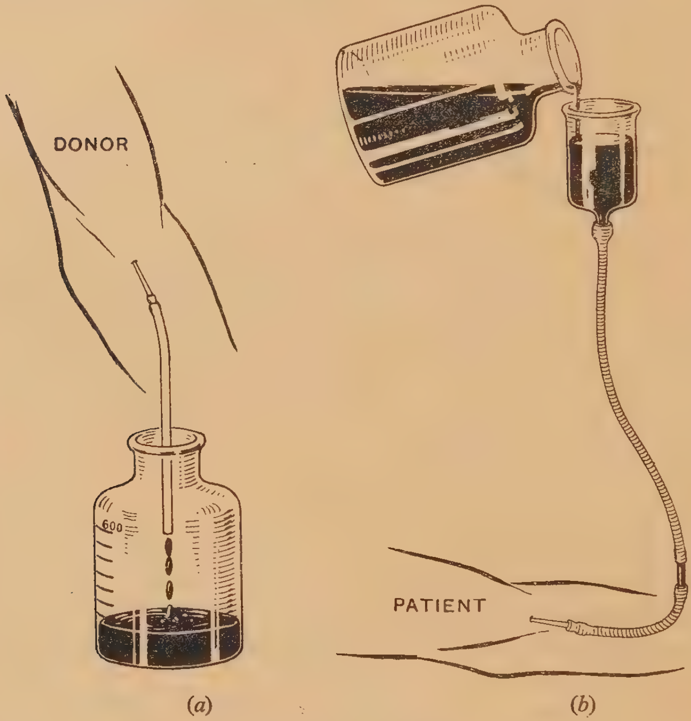

FIG. 80.—Simple emergency technique
(*a*) Collection of blood. (*b*) Transfusion by gravity

Apparatus

The blood is collected in a Dewar's liquid air 'vacuum flask' of about 1,000 c.c. capacity, which, though having a round base, is supplied by the makers in a hollowed wooden stand which holds it securely. When this flask is filled with liquid at 37° C., lightly plugged with wool and allowed to stand at room temperature, the fall in temperature of the contents is less than 1° C. per hour. In it freshly drawn blood can be kept without any change due to cooling. A supply of sterile physiological saline and sterile 3 per cent citrate in two ordinary flasks is placed in a basin of hot water to warm them to about 45° C.

The inside of the sterilized Dewar flask is warmed by pouring in 250 c.c. of hot physiological saline. After a few minutes this is poured away and replaced by 50 c.c. of 3 per cent citrate. The flask is now closed by a three-holed rubber cork which is already sterilized and carries (*a*) a short curved glass tube attached to a rubber suction bulb, (*b*) a glass-tapped thistle funnel which reaches nearly to the bottom of the flask and has etched along its stem rings clearly indicating the level of each 100 c.c. of liquid in the flask and (*c*) a simple short glass tube which has been attached, after running a little sterile citrate through it, to the rubber tube leading to the donor needle. The general arrangement is shown in Fig. 82.

Procedure for collection

By working the bulb a negative pressure can be produced at the needle. The thistle-funnel tap is closed. The donor's arm having been prepared and the vein distended by application of a loose tourniquet the needle is inserted from below upwards, and when in the proper position is held there by a small strip of skin strapping. The flow of blood is accelerated if necessary by suction. The flask is kept gently moving by the nurse who holds it. At the start it contained enough citrate (50 c.c.) for 250 c.c. of blood, which is usually collected very quickly. When the total volume in the flask reaches about 300 c.c., a little more citrate is run in through the thistle funnel, so that for every 100 c.c. of blood there are 20 c.c. of 3 per cent citrate present. Excess is thus easily avoided. As soon as enough blood is withdrawn the pressure is released by opening the thistle-funnel tap, the needle is withdrawn from the donor's arm and the Dewar flask placed upon its wooden stand. There it can remain without any fear of cooling too much. The cork with its attachments, which are not needed again, is removed and the flask plugged with sterile gauze.

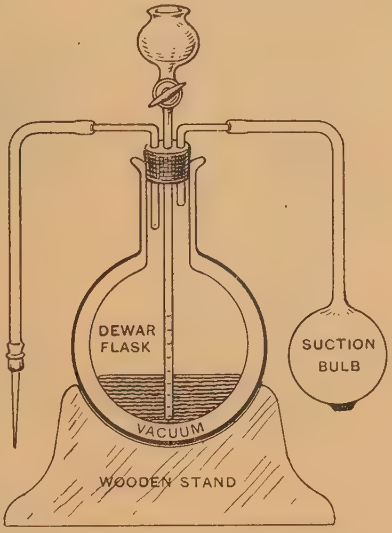

FIG. 81.—Dewar's vacuum flask (*Practitioner*, 1935)

Administration to recipient

The blood can now be transfused into the patient directly from the Dewar flask. The transfusion apparatus is brought to the patient assembled and sterilized. Its essential part is a Record type 25 to 50 c.c. syringe with a simple Y-shaped nose-piece. At the junction of the two branches of the nose-piece is a simple lever tap, by a half turn of which the syringe can be put into communication with either branch. From one branch a rubber tube leads to a straight glass tube long enough to reach to the bottom of the Dewar flask. From the other branch a rubber tube runs to the patient's needle. In this tube a short glass 'window' is inserted about an inch from the needle.

In an earlier paragraph the supply of sterile physiological saline was mentioned. By manipulating the taps and syringe, the whole of the above apparatus is filled with this saline, all bubbles being expelled. The straight tube is pushed down to the bottom of the Dewar flask containing the blood and, again by working the syringe and taps, continuity of flow is tested. The patient's arm is prepared, the needle inserted and its position verified by noting the back-flow of blood in the 'window'. Again a small piece of strapping will hold it firmly in position. By appropriate use of the syringe and taps the transfusion can now be carried through.

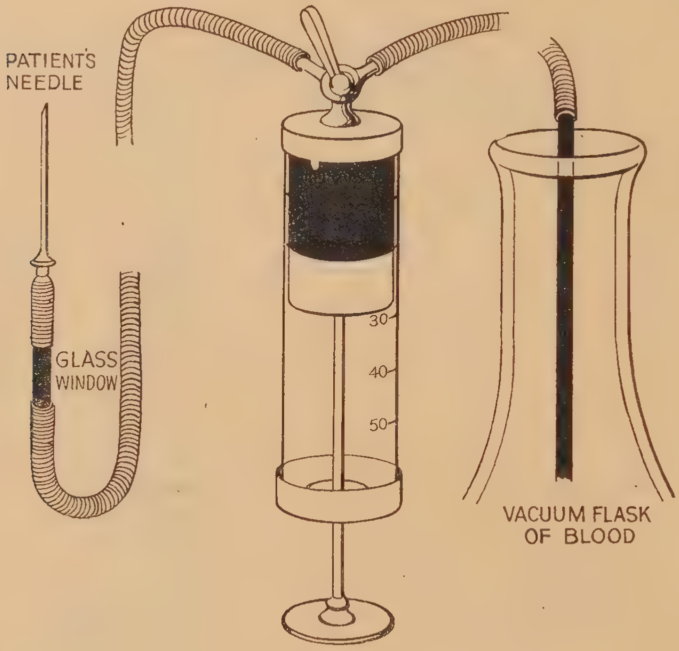

FIG. 82.—Transfusion syringe

By this method both the rate of withdrawal of blood from the donor and its transfusion into the patient can be regulated perfectly, the pressures are throughout completely under the operator's control, and excess of citrate and overcooling are to a large extent avoided. It allows the operator to withdraw blood from and transfuse into relatively small veins and to use much smaller and less painful needles than with the gravity methods. It is practically never necessary to cut down on veins and the method is particularly effective for the small veins of infants less than one year old, in whom it may be necessary to use the superior longitudinal sinus, the external jugular, the saphenous vein or one in the scalp.

In the two methods described the main principles involved have been discussed; the exact details may be left to the choice of the operator.

Methods of continuous transfusion

In recent times the procedure known as continuous drip-transfusion has been perfected and is now frequently used when the patient is bleeding continuously or has become extremely anaemic and it is urgent rapidly to raise his haemoglobin percentage to a clinically safe level. The principle of the apparatus involved is that of the old continuous-drip saline infusion. Some operators prefer always to cut down on the patient's veins and to insert a small glass cannula which can be kept in place for many hours; others use only needles carefully retained in the vein. In either case blood is run into the patient's vein from a warmed reservoir into which citrated blood from a succession of previously matched, appropriate donors has been placed at intervals. In this way relatively very large amounts of blood can be run slowly into the patient's circulation—and the haemoglobin percentage and red count may be raised with remarkable rapidity. The disadvantage of the method is that the apparatus is a little complicated and the continuous method requires a continuous watch on the patient. On the other hand, in cases of great urgency, such as haematemesis, the rapidity of improvement in the patient's blood makes it worth while, although in most cases, a few separate transfusions as already described are easier to manage, less exacting to donors and just as effective.

5.–REACTIONS AFTER TRANSFUSION

The most frequent type of reaction

Avoidance of reactions is of great importance. About 20 per cent of patients receiving a blood transfusion show within twenty-four hours a simple febrile reaction which may be accompanied by headache, nausea and vomiting. The type of reaction is of little consequence and soon passes; although it causes discomfort, it has no serious significance and is usually to be ascribed to one or more of the following: cooling of the blood, excess of citrate, too rapid transfusion, or impurities in chemicals or rubber tubing. Avoidance of these simple reactions is largely a matter of technique in transfusion. Of particular importance is the use of freshly distilled water for the preparation of saline and citrate; dead organisms in sterile solutions made up with old distilled water are a potent cause of reactions.

There are two distinct types of more immediate reactions which are usually not dangerous and a third, due to blood incompatibility, which is.

Rigors

Rigors and minor degrees of shock may be dealt with by subcutaneous injection of 3 to 5 minims of 1 in 1,000 adrenaline hydrochloride solution, and provision of hot water bottles. To reduce their incidence it is a good practice to give an injection of ½ to 1 grain of ephedrine hydrochloride about a quarter of an hour before the transfusion.

Allergic reaction

Should the patient be known to have allergic tendencies the donor should be used fasting to avoid excess of foreign protein in his blood and the patient should not be transfused more than once from the same donor, particularly if there was any trace of reaction during the first transfusion.

Reaction due to incompatibility

Dangerous reactions should never be seen as they are due to incompatibility and occur only when the bloods have not been properly matched. At the first sign of this type of reaction the transfusion must at once be stopped. The effect of a small quantity of incompatible blood upon a conscious patient is that he quickly becomes restless, experiences generalized tingling sensations and then definite pain in the back and thorax. If more blood be given, there is flushing of the face, respiratory and general distress followed by collapse with clammy skin and feeble pulse. Subsequently the temperature rises, the patient becomes jaundiced, and haemoglobinuria is followed in fatal cases by uraemia. The conscious patient will himself call attention to the onset of this type of reaction, but with the unconscious or anaesthetized patient we can only watch the pulse and respirations with the greatest care and stop the transfusion at the first sign of distress. Immediate treatment consists in the subcutaneous injection of 5 to 15 minims of 1 in 10,000 adrenaline solution and up to $\frac{1}{100}$ grain of atropine. As a safety measure it is wise in all transfusion cases, if time allows, to give the patient sufficient alkali by the mouth to render the urine definitely alkaline. The reason is that, when incompatible cells enter the patient's circulation, they are rapidly clumped and haemolysed, and the liberated haemoglobin, although in part excreted in the urine, is also, if the urine is acid, precipitated within the renal glomeruli as a derivative of acid haematin, interfering with renal function. There is evidence that if the urine is alkaline this precipitation does not occur. The precaution of giving excess of alkali is so simple that it should always be taken.

Treatment of reactions

6.–INDICATIONS FOR TRANSFUSION

(1)—The Anaemias

Post-haemorrhagic anaemia

If in post-haemorrhagic anaemia there is any doubt as to the patient's ability to restore his blood-volume and supply of corpuscles quickly enough, transfusion should be undertaken. In estimating the necessity for transfusion it is important to note by blood counting the exact degree of deficiency to be made good and, by appropriate tests, whether the loss of blood still continues. If the haemorrhage was recent and the haemoglobin percentage is not below 25 per cent, an otherwise healthy patient will not usually require transfusion. If the haemorrhage is continuing or there is likelihood of its recurrence in the immediate future, it is safer to transfuse as soon as the haemoglobin level has fallen to 35 per cent.

The position is different if the haemorrhage occurred some weeks earlier and the patient's haemoglobin is found still to be standing at 35 to 40 per cent, and showing poor power of regeneration. Although this figure does not indicate a dangerous level, yet one transfusion may stimulate the activity of the blood-forming tissues. Further, if the patient has remained at this low level because of slight recurrent haemorrhage, the introduction of new healthy blood may put an end to the blood loss by improving clotting power.

Deficiency of blood production

Deficiency of blood production may be as dangerous as blood loss and may arise from a number of causes. The most obvious is exhaustion such as occurs after a series of repeated small haemorrhages or at the end of a long illness. Direct damage by chemical poisons, particularly the nitro-compounds and arsenicals, can quickly depress blood production, and the same may be said of irradiation by X-rays or radium. The result of prolonged septic absorption is similar. Sometimes no reason for the aplasia can be found but it is always possible that, if relieved of strain, the haemopoietic system may recover some or all of its function.

The only method of providing relief when iron, liver, and vitamin therapy fails, is repeated blood transfusion. The object should be to maintain the haemoglobin level at at least 70 per cent over long periods. It is best to begin with frequent transfusions and reduce the number as the bone marrow responds. Estimations of the reticulocytes should be made at intervals and an increase in their number is the first sign of haemopoietic recovery. Even when the aplasia is found to be permanent, life may be prolonged by transfusions at regular intervals.

Pernicious anaemia

Although in the past many cases of pernicious or Addisonian anaemia were successfully treated by transfusion, the advent of potent preparations of liver for intramuscular injection has rendered transfusion unnecessary in most cases of this disease. But refractory cases are sometimes encountered and a single transfusion will then often give the patient a start, after which liver treatment will complete the process. The macrocytic anaemia of pregnancy which is usually transient and amenable to liver therapy does not often call for transfusion unless the patient comes under observation late or shortly before parturition, in which case it may be advisable to take advantage of the extremely rapid effects obtainable only by transfusion.

Acholuric jaundice

In acholuric jaundice transfusion may be necessary if the anaemia is severe and particularly as a preliminary to splenectomy. Care must be exercised as severe haemolytic reactions have been reported after transfusion in acholuric patients.

Acute haemolytic anaemias

In the more rare, rapidly advancing, acute haemolytic anaemias of infancy and adult life transfusion appears to be the only method of treatment and has the advantage of controlling the anaemia while diagnostic investigations are being undertaken.

Anaemias of infancy

The cure of the severe infantile anaemia associated with various conditions, such as rickets, tuberculosis and syphilis, and formerly known as von Jaksch's anaemia, clearly depends upon relief of the underlying disease. But in practice, if the anaemia is severe, it is best to improve the blood condition first by transfusion, and to investigate the other problems later. Among the anaemias of early life is that described as the hyperchromic anaemia of infants which also is benefited by small transfusions.

Although instances have been mentioned in which transfusion is effective as a continued treatment, in children, as in adults, a wise *initial* treatment of any patient in which the haemoglobin percentage has fallen below 25 per cent, especially if the white cell and reticulocyte counts are also low, is one or more blood transfusions. After this the difficult task of determining the exact cause of the anaemia can be carried through systematically and appropriate treatment instituted.

(2)—The Haemorrhagic States

Haemophilia and essential thrombocytopenia

Haemophilia and thrombocytopenia are both to some extent controlled by transfusion. In haemophilia fibrin formation is defective; in essential thrombocytopenia clot retraction fails owing to a deficiency in the number of circulating blood platelets. In both conditions transfusion can be used to tide over the acutely haemorrhagic crises which are liable to occur. If any surgical procedure must be carried out on these patients, even a simple tooth extraction, a small preliminary transfusion is indicated, and its effect on the bleeding time and coagulation time should be checked before the operation is performed. The effect on haemophilia is temporary and a second transfusion a few days after operation may be advisable to maintain the clotting power of the blood until healing is complete.

Haemorrhagic disease of the new-born

In haemorrhagic disease of the new-born transfusion is the most necessary treatment. But it must not be assumed that all anaemic patients who show purpura will necessarily benefit from transfusion. In all these cases the leucocyte count should be investigated so that instances of leukaemia may not be overlooked. Should the patient be in the late and haemorrhagic stage of a leukaemia, blood transfusion is useless and leads only to disappointment.

(3)—Acute Infections

Whilst it is obvious that if a patient suffering from any acute infection shows severe anaemia and a deficient white count, he should benefit from transfusion, there is still much uncertainty as to how much improvement can be expected. It is true that the blood picture can be rapidly improved and the resistance of the tissues raised by the introduction of new blood. But if the anaemia is not marked and the patient is producing a reasonably good leucocytosis, the introduction of a few more healthy cells cannot greatly influence matters. If the haemoglobin percentage and white count are really low, transfusion is clearly indicated. In other circumstances any good a transfusion can do depends upon the possibility that the in-going blood carries with it antibodies against the infection. The bulk of available evidence favours the use of transfusion (*a*) in septicaemia and pyaemia of recent origin, especially when it is possible to immunize the donor to the infection concerned; (*b*) in fulminating cases of the acute fevers against which the serum of a healthy

Indications for transfusion

adult donor is known to contain powerful antibodies; (*c*) in various types of chronic sepsis in which the patient has become markedly anaemic and in which transfusion may be expected to repair the anaemia, raise tissue resistance and so promote healing; and (*d*) on those occasions when the patient is resisting poorly a local infection, such as mastoiditis, and yet bacteriological examination shows that the organism concerned, e.g. a non-haemolytic streptococcus, is not very virulent. Repair of tissue resistance by blood transfusion may rapidly clear the infection.

(4)—Surgical Cases

Anaemic patients before operation

One of the greatest achievements of blood transfusion is seen when, before a major surgical operation is performed upon a patient with anaemia, the general condition can be greatly improved, with corresponding reduction of the surgical risk. This is particularly the case when the operation concerns an infective condition in which septic material has been or will be liberated and come into contact with the tissues. Apart from the obvious benefits from the improved general conditions and blood picture, the added antibacterial and antitoxic powers of the newly added blood may greatly influence the patient's condition during the first critical hours following operation. When operations have to be performed on jaundiced patients, a small preliminary transfusion will usually reduce the tendency to post-operative bleeding which these patients so often exhibit.

Jaundiced patients

(5)—Coal-Gas and Similar Poisonings

In emergency states such as carbon monoxide and cyanide poisoning, in which the oxygen carrying capacity of the blood has been dangerously impaired, the only means of bringing rapid and immediately effective relief is blood transfusion.

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BOCKHART'S IMPETIGO

See BARBER'S RASH, p. 289; *and* IMPETIGO

BOILS AND CARBUNCLES

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Reference may also be made to the following title:

CELLULITIS

1.–BOILS

173.] A boil or furuncle is a localized inflammation of the skin, usually terminating in pus formation. It is caused by the infection of a hair follicle or sebaceous gland with the *Staphylococcus pyogenes aureus.* *Definition*

(1)—Aetiology, Pathology and Bacteriology

Aetiology Although boils may occur in otherwise healthy individuals, they are most commonly seen in patients who are run down in general health, either through overwork or poor food. In cases of recurrent boils some constitutional disorder, such as chronic kidney disease or diabetes, exists. The quality of the skin also seems to be a factor, coarse skins which are liable to comedones being more frequently affected. In patients with recurrent boils in the axilla, Whitfield states that the use of anti-perspiration preparations is particularly harmful.

Bacteriology The staphylococcus frequently gains entry to a hair follicle or sebaceous gland through a minor trauma such as might be caused by depilation or by scrubbing with a nail brush; the common sites are the back of the neck, the axillae and the lower extensor aspect of the forearm. The resulting inflammation is acute, and causes gangrene of the hair follicle and of the surrounding connective tissue. The slough is separated by suppuration. In its complete form the boil consists of a slough (the core) surrounded by pus, with an outer zone of granulation tissue merging into normal skin and connective tissue. When the boil discharges, the surrounding skin is bathed in pus which may infect neighbouring hair follicles and produce a number of 'satellite' boils.

(2)—Clinical Picture

A boil commences as a small, red, irritable spot, the irritation frequently preceding any visible lesion. The area affected gradually increases in size and becomes more and more painful. It has then the appearance of a small conical tumour; the covering skin is shiny and dark red, and at the apex is a small white spot, over which the skin finally gives way. The central slough either liquefies and is discharged as pus, or comes away *en masse*, after which the process is at an end and healing rapidly takes place. *Lymphangitis* In some cases a lymphangitis occurs with enlargement of the neighbouring lymphatic glands. This secondary inflammation usually subsides but may be followed by abscess formation in the infected lymph glands. *Septicaemia* If the patient's resistance is greatly lowered, a fatal septicaemia, most frequently in the form of a septic pneumonia, may result.

(3)—Course, Prognosis and Diagnosis

Prognosis The majority of boils burst and heal without medical attention but some, which are known as 'blind' boils, leave the part thickened and infiltrated for some time, and do not form pus. Except for depression, constitutional symptoms are usually absent; but when lymphangitis or lymphadenitis develops fever and malaise are present in varying degrees. *Diagnosis* The diagnosis is straightforward: occasionally an infected sebaceous cyst may be mistaken for a boil, but usually the history of previous swelling can be obtained.

(4)—Treatment

Fomentations The treatment of boils has undergone considerable change. It is now recognized that conservative treatment should be employed. When the boil is first seen, hot boric acid or mercuric chloride (1 in 4,000) fomentations should be applied at frequent intervals. The small necrosed area of skin on the apex should be gently removed with dressing forceps; a discharge of pus or serum follows, and as the inflammation progresses, more and more discharge is found on the dressings. The small central opening should be kept clear of crusts and slough in order to promote discharge. On no account should an incision be made into the infected area as this may cause lymphangitis, or even septicaemia; rough dressing, squeezing or suction by any form of suction glass should be avoided. Attention should be given to the bowels and diet, and a tonic, such as iron and quinine, is to be recommended.

Treatment of recurrent boils If patients have crops of boils it is advisable to try an autogenous vaccine during a quiescent period. If vaccine treatment appears to do little good, a tin preparation (e.g. stannoxyl or compound tin tablets N.F.:—tin 1·7 grains, tin oxide 0·3 grain) may be given orally, or injections of colloidal manganese (1 in 400), ½ to 2 c.c., every three or four days. If the boils recur in one situation, such as the axilla, bathing the part with mercuric chloride lotion (1 in 4,000) may prove effective, and in some cases a bath of zinc sulphate solution (1 in 1,200 to 1 in 800) may be advised.

2.–CARBUNCLES

Definition 174.] A carbuncle is an infective gangrene of the subcutaneous tissues, more extensive than the boil, and is due to the invasion of the tissues by pyogenic organisms, most commonly the *Staphylococcus pyogenes aureus*, and occasionally the streptococcus.

(1)—Aetiology, Pathology and Bacteriology

Incidence A carbuncle occurs in patients who are run down, in those whose resistance is greatly lowered by debilitating diseases such as albuminuria or diabetes, and is occasionally a sequel to acute fevers and blood diseases. Men are affected more commonly than women in the proportion of about three to one.

The lesion is determined by local lowering of resistance by a blow or squeeze resulting in a slight effusion of serum or blood, or by repeated small traumas such as may be caused by the chafing of clothes. The staphylococcus gains entry sometimes through a slight abrasion but more commonly by a sweat gland or hair follicle.

Bacteriology The infective agent is generally the *Staphylococcus pyogenes aureus*, which sets up inflammation so acute as to produce local gangrene with the formation of sloughs. These sloughs are at first separate islands, but as the pressure from effusion increases, further gangrene occurs until the central portion is one confluent slough around which is an area of further island necrosis, and on the periphery a zone of acute hyperaemia. As the tension increases, vesiculation takes place on the surface, due to oedema; these vesicles are later replaced by small points of suppuration, and if the tension is great a portion of the skin, varying in size, is destroyed.

(2)—Clinical Picture

A carbuncle starts as a hard, indurated and painful swelling in the subcutaneous tissues, the skin over it being red, and later dusky. The circular swelling increases until it covers an area of several inches; pain becomes more intense and the character of the swelling changes; the central portion becomes boggy and the skin oedematous, while the peripheral region remains densely indurated. Small blisters appear in the oedematous area, followed by pustules which discharge and inefficiently drain the underlying slough. Several of these sinuses may join, producing an ulcerated area varying in size; a greyish-yellow slough which is unusually tenacious can be seen. The lymphatic glands draining the area are enlarged and tender, but rarely go on to abscess formation. The patient shows marked constitutional disturbance, with much rise in temperature, due to absorption of toxins and to exhaustion from pain and sleeplessness. The urine may contain albumin or sugar; the sugar may be due to a toxic glycosuria or may indicate that the patient is diabetic. As the inflammation settles, the sloughs liquefy or are discharged, leaving a granulating wound which gradually contracts and heals.

General symptoms

(3)—Course and Prognosis

Prognosis

The course run by a carbuncle varies with its location. The common situations are the neck, back and nates, where the vitality of the subcutaneous tissue is low, and the skin dense. As a result the inflammatory process is usually more prolonged and the drainage more inefficient than in situations such as the thigh or abdomen.

Carbuncle on the cheek and lip

In the cheeks and lips, special anatomical conditions alter the course and prognosis. The subcutaneous tissues in this area are more spongy, and rapid extension may take place. Owing to the thrombosis in the surrounding vessels and the vascularity of the parts, the lips and cheeks offer increased facilities for the spread of the infection both locally and generally. In the case of the upper lip and cheek the venous drainage is towards the angular vein and hence to the cavernous sinus. A spreading thrombus frequently takes this route with a fatal issue. The local signs are spreading oedema towards the internal canthus of the eye, and later closure of the lids. The temperature and the pulse-rate rise. In such cases it is important to force the lids apart and observe the eye movements. As long as these are present the cavernous sinus is not affected, but when thrombosis takes place in the sinus there is complete paralysis of all eye movements owing to the pressure on the third, fourth and sixth nerves. It is then merely a question of days or even of hours before the thrombus spreads to the other cavernous sinus and death ensues.

All carbuncles may end fatally from septicaemia, the terminal condition being usually septic pneumonia, but there is greater risk of general infection in carbuncles on the face. In some cases chronic pyaemia supervenes, but rarely ends fatally; the abscesses form at longer intervals and are aspirated, until in due course they disappear.

Mortality

In a series of 240 severe cases collected by Mitchiner at St. Thomas's Hospital (170 males and 70 females), the mortality rate was 5·8 per cent. Of these 83 had facial carbuncles and the mortality was 8·4 per cent. As Mitchiner points out, all the patients with facial carbuncle were probably admitted to hospital when first seen, whereas probably only a third of the others were admitted. This means that the death-rate in the latter type is considerably lower than the above figures suggest. In the case of carbuncle occurring in the true diabetic the prognosis is less satisfactory, and in great part depends on the control of the diabetes.

(4)—Treatment

Treatment

The treatment of carbuncles, as of boils, has undergone considerable change in the last few years. Most surgeons recommend conservative measures and there can be little doubt that this modern view is correct. Difficulty arises in deciding which cases require active surgical intervention. Conservative treatment consists in resting the part, and applying hot fomentations at two-hourly intervals; fomentations may be omitted and the carbuncle smeared with magnesium sulphate paste; or a combination of the two methods may be used. The magnesium sulphate paste greatly increases the flow of lymph into the affected area and thus facilitates liquefaction of the slough whilst localizing the infective process. The magnesium sulphate paste treatment was first introduced by A. E. Morison of Sunderland, who insisted that to be effective the paste should be made from magnesium sulphate dried so as to contain 12 per cent less water than ordinary commercial Epsom salts. His formula for magnesium sulphate paste is as follows: anhydrous magnesium sulphate, 24 ounces, glycerin of phenol (1 in 10), 11 ounces. Numerous modifications of Morison's paste have been suggested; probably the B.P.C. formula—exsiccated magnesium sulphate 45, glycerin 55, phenol 0·5—is an improvement. The paste is applied directly to the affected area. Twice a day the discharge is gently removed and any sloughs are helped to separate with dressing forceps. The patient is kept on a light, nutritious diet, and the bowels are opened by calomel and salts, followed by a daily saline purge.

Magnesium sulphate paste

Autohaemotherapy

A line of treatment which falls between conservative and more active measures is the introduction of a few cubic centimetres of whole blood round the infected area. This blood is obtained from the patient and presumably helps to introduce into the affected area antibodies which, owing to the thrombosis and sloughing, would not otherwise get there. The value of this treatment is doubtful and it may naturally increase the pain, which, in any case, may be so severe as to require the use of drugs to promote sleep.

Surgical treatment

Incisions should never be made. Tension of the part owing to the presence of small separate areas of necrosis is not reduced by incision, but this may spread infection to the blood-stream with disastrous results.

Excision

If excision of the whole of the infected area is necessary, a large crucial incision should be made and the four skin flaps thus marked out should be undercut and turned back. These flaps are usually viable, however damaged they may have previously appeared. The thick and oedematous sloughing tissue beneath the skin is then cut away, exposing the underlying muscle. The opening is packed with 1 in 1,000 acriflavine solution and paraffin gauze, and the flaps returned to position. The pack can be left for four days, when a daily eusol pack should be substituted, and hot fomentations applied. This method of excision reduces very considerably the convalescent period, and skin grafting as a final procedure is rarely necessary. During the healing stage the use of short-wave diathermy is most beneficial.

Contra-indications to surgical treatment

It cannot be too clearly emphasized that active surgical intervention should rarely be employed. The cases which require it are only those in which the carbuncle, usually situated on the back of the neck, is so large that the length of the illness will be reduced by cutting out the infected slough, or in which a toxic glycosuria is present. If septicaemia or pyaemia threaten, excision should be used only when the carbuncle has ceased to spread, otherwise there may be a fatal ending; the same applies to the true diabetic, more especially in those cases in which the diabetes is difficult to control. Facial carbuncles should never be incised, or excised, the risk being too great.

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BONE DISEASES

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Reference may also be made to the following titles:

ACHONDROPLASIA
EPIPHYSES, DISEASES AND INJURIES
FOETUS DISEASES, MALFORMATIONS AND MONSTROSITIES

Development of bone

175.] Bone develops in one of two ways: in intramembranous ossification the connective tissue cell is transformed directly into bone; in endochondral ossification the connective tissue cell is transformed into a cartilage cell which calcifies, and the calcified cartilage cell is then absorbed and replaced by bone, which is laid down in a regular pattern by a specific type of cell called the osteoblast.

There may be an arrest or perversion of endochondral ossification, giving rise to achondroplasia, which is described in Vol. I, p. 135; or of intramembranous ossification giving rise to anosteoplasia (see p. 556). Moreover, in endochondral ossification, the osteoblasts responsible for absorbing the cartilage cell and laying down bone in its place may be lacking, giving rise to the clinical condition known as osteogenesis imperfecta (see below). After birth, increase in the length of the long bones takes place at the growth disc. Cartilage cells are produced in orderly rows, and become calcified; they are then absorbed by osteoblasts and bone lamellae are laid down in their place. Sometimes this process becomes disorderly, a condition known clinically as dyschondroplasia (see p. 556). Apart from these clearly defined dystrophies, there are other irregularities of bone growth, which conform to no type; these are grouped together under the term chondro-osteoplasia.

1.–CONGENITAL BONE DYSTROPHIES, GENERALIZED

(1)—Idiopathic Fragilitas Ossium

Definition

This is not a disease, but a symptom which occurs in many diseases, congenital or acquired. It may be due to developmental defects, or to local or general bone absorption. When due to developmental defects it is called idiopathic fragilitas ossium. This term includes two well-defined clinical conditions—osteogenesis imperfecta, and marble bones (see below and p. 555).

(*a*) *Osteogenesis Imperfecta*

Clinical picture

This is characterized by a congenital defect in the evolution of the osteoblasts, and is recognized clinically by defective ossification of the skull, and multiple fractures. Many of those affected die either at birth or within a few months of birth from the damage done to the unprotected brain during labour. The skull at that time consists only of a membranous bag with a few small isolated plates of bone. Those who survive usually come under medical supervision in early childhood for a succession of fractures, caused by trivial injuries.

The condition is due to an hereditary hypoplasia of the mesenchyme, and all the fibrous structures of the body are involved, but bone fragility is the obvious clinical sign. The fractures are not spontaneous, but result from mild traumas. They are often incomplete and may therefore be overlooked until the development of secondary deformity. The shafts of the long bones alone are affected. Non-union is rare; union in fact takes place rapidly although firm consolidation occupies the usual time. The bones are of normal shape, and it is only after a series of malunited fractures that the limbs appear bent. The bones are in fact brittle rather than soft, and radiography shows that they are slender and atrophic; the epiphyses are normal.

The other characteristic of the condition is the china-blue colour of the sclerotics, caused by an abnormal translucency of fibrous tissue, which allows the uveal pigment to shine through; microscopically the sclera are normal. The weakness of the fibrous structures of the body causes a hypermobility of the joints and a liability to recurrent joint sprains and dislocations.

The liability to fracture lessens as the child grows and few fractures occur after puberty. Radiography (see Plate VII, A) then shows that the slender bones, instead of being atrophic, are sclerosed and indistinguishable in their density from 'marble bones'. It seems as though the body, lacking the power of laying down normal bone along definite lines of stress, attempts to strengthen the structure by laying down an excess of calcified material in a conglomerate mass. This subsequent sclerosis of bone accounts for a further symptom, namely, progressive deafness, which develops later in life and is due to otosclerosis.

Morbid anatomy

Microscopical examination of the bone shows that osteoblasts are absent; calcareous deposits are laid down in a connective tissue groundwork, with the formation of irregular trabeculae with large intervening spaces. The skull is mis-shapen, the antero-posterior diameter is shortened and the bitemporal diameter increased; the ears are thus turned down and out and give a characteristic appearance to the face. The children are normal in every other way, mentally and sexually. There are no endocrine disturbances, and the blood chemistry is not abnormal.

Aetiology

Nothing is known about the cause. The condition is hereditary, is transmitted by male and female and does not skip a generation. Fifty per cent of the children will inherit the disease.

Treatment

Treatment consists in protecting the children as far as possible from trivial accidents, and in treating the fractures as they arise. Deformities of the limbs are due entirely to faulty treatment of the fractures; these may be overlooked until deformity has occurred. The brittleness of the bones may necessitate almost continuous recumbency until puberty.

(*b*) *Osteosclerosis Fragilis Generalisata* (*Marble Bones*)

Albers-Schönberg's disease

This is a rare disease, sometimes called after Albers-Schönberg, who in 1904 first described it. It is difficult to define its relationship to osteogenesis imperfecta. The X-ray appearances of the bones in the late stages of osteogenesis imperfecta are similar to those of marble bones; the density of the bone is much increased and the structure of the bone obscured by contiguous masses of opaque calcareous deposits. The two conditions, however, are not the same.

Albers-Schönberg differentiated marble bones from another condition which he called osteopathic condensans disseminata. In it there is a dense deposit of calcium salts in the bones, but the areas are not contiguous, and the bone has a mottled appearance. There is no liability to fracture and the secondary effects noted in osteosclerosis fragilis generalisata do not occur. The condition is clinically silent and is only discovered by a chance radiogram.

Clinical picture

Marble bones may be diagnosed in childhood as the result of a fracture, but although the bones are more brittle than usual they do not break as easily as the bones of osteogenesis imperfecta, and a succession of fractures is uncommon; moreover, the sclera are not blue. Often the disease is undiagnosed until adult life, when attention is drawn to it by the mechanical effects of the sclerosed bone. There may be deposition of bone at the base of the skull with a consequent diminution in the size of the nerve foramina, and optic atrophy and ocular palsies may appear. In the long bones the progressive sclerosis leads to an obliteration of the medullary canal and a secondary involvement of the haematopoietic system. An attempt is made to compensate for the loss of the blood-cell factories by the enlargement of the spleen and lymph glands, and if this is unsuccessful an aplastic anaemia develops. Nothing is known about the aetiology or treatment of marble bones.

(2)—Achondroplasia

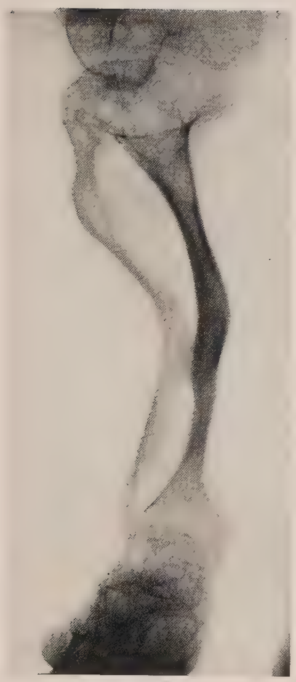
This condition is discussed in Vol. I, p. 135.

(3)—Anosteoplasia (Hereditary cranio-cleido-dysostosis)

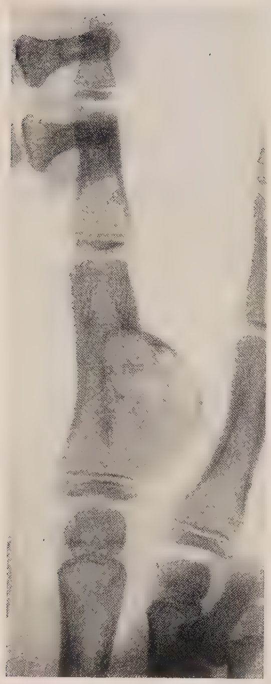
This name is given to a condition in which there is an absence or perversion of the normal process of membranous ossification affecting all bones derived from membrane. Like achondroplasia, the condition is hereditary and the aetiology unknown. The patients are small for their age. The head is large and the fontanelles patent. Dentition is delayed and the milk teeth persist for a long time. The trunk is normal. The outer halves of the clavicles are absent, and the shoulders can be brought together in front of the chest; this, however, does not impair the function of the arms. The pubic bones may be similarly absent. The limbs seem normal, although the radiogram may show an infantile type of coxa vara deformity. The toes are short, the terminal phalanges appearing as though they have been nibbled off.

(4)—Dyschondroplasia (Multiple Chondromas)

In this condition growth at the epiphyses is disorderly in direction, quality and quantity. The diagnosis is made by radiography. In the radiogram (see Plate VIII, A) the last inch or more of the metaphysis consists of a broad irregular-shaped area, in which the normal cortex and medulla are replaced by bubble-shaped spaces of diminished density resembling cysts; microscopically this is shown to be an irregular conglomeration of bone, cartilage and connective tissue. The remainder of the shaft may show dense striae, or dense spots, or small translucent



A.—Osteogenesis imperfecta



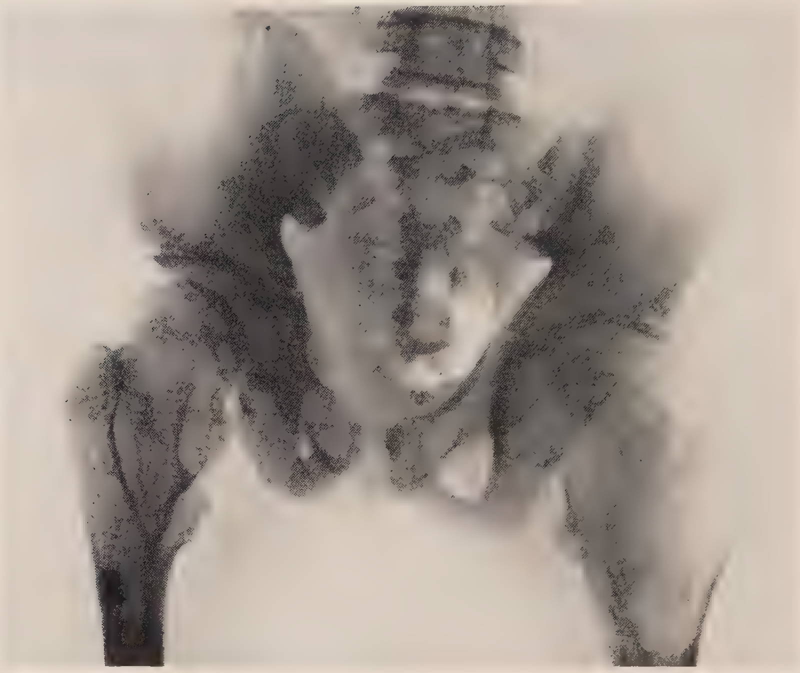
B.—Chondroma in phalanx

C.—Osteolytic osteogenic sarcoma. Middle of shaft of humerus. There had been a fracture, which clinically was united

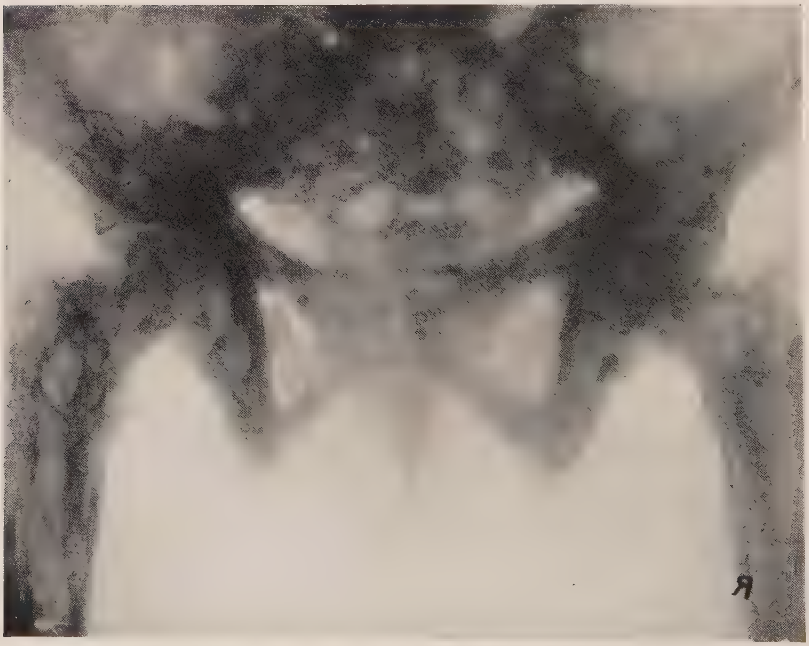
D.—Same bone as C. Three months later

PLATE VII

[*To face p.* 556



A.—Dyschondroplasia



B.—Osteitis deformans

PLATE VIII

[*To face p.* 557

areas but is otherwise normal. The enlarged ends of the bones may restrict joint movement. The rate of growth at the epiphyseal line may be altered so that deformities develop, e.g. at the wrist (ulnar deviation because the radius grows more quickly than the ulna), and at the ankle (valgus deformity because the tibia grows more quickly than the fibula). Angulation of the bones may occur from the growth disc developing in an abnormal direction; genu valgum is common. The epiphyses may be stippled in the radiogram but are otherwise normal. At the affected metaphyses, outgrowths from the disorderly mass may project from the shafts and be indistinguishable clinically from multiple exostoses (see p. 582). Usually all the long bones exhibit the condition; but sometimes it is limited to one half of the body, as in the patients originally described by Ollier, who isolated dyschondroplasia as a clinical entity.

In two-thirds of the cases the parents are also affected. It is much commoner in boys than girls and is usually diagnosed in early childhood. The patients complain of a lump, which may be the enlarged metaphysis or an exostosis, or of a short limb, or of a joint deformity or, rarely, of restricted range of movement at a joint. There is no pain unless an exostosis interferes with the action of a tendon or presses on a nerve. The patients, except for the skeletal affection, are normal. Treatment may be required for mechanical reasons, to correct a deformity or to remove an exostosis. Rarely an area of cartilage remains embedded in the shaft and later in life undergoes malignant change.

(5)—Arachnodactyly

A rare condition, less rare in girls, in which the hands and feet are relatively too long for the height. The children are unusually tall and thin and from weakness and poor resistance are liable to succumb to acute infections. The length and slenderness of the fingers are accentuated by the deficiency of the soft parts. The muscles are hypotonic and as a result there is great laxity of joint ligaments. There are often other congenital stigmata such as congenital dislocation of the lens with trembling irides, small contracted pupils, irregularly deep anterior chambers and a limited reaction to dilatation by atropine (Ormond and Williams). Thoracic deformity occurs in about 50 per cent of cases, and cardiac lesions in about the same proportion (Burch).

The condition has been ascribed to endocrine disorder, but is more probably, like mongolism, a developmental defect in which heredity plays a part (Young).

2.–CONGENITAL BONE DYSTROPHIES, LOCALIZED

176.] The foetal limb bud consists of (1) a root segment near the trunk, (2) an intermediate segment which separates into two parallel segments, and (3) a terminal segment which separates into five parallel segments. Abnormalities may occur in the growth of the limb buds, resulting in suppression, hypoplasia or hypertrophy; and abnormalities may occur in the segmentation of the limb buds, resulting in either the production of supernumerary segments, or a fusion of segments.

Suppression of limb buds

Ectromelia is the name given to suppression of part or the whole of a limb, and phocomelia to the suppression of the proximal segment. Congenital absence of the upper half of the femur is the commonest example of phocomelia (see Fig. 83). Actually, although no evidence of bone is visible in the radiogram when the condition is discovered, the upper end of the femur is usually present as a bar of cartilage, which later becomes ossified. The femur is very short and there is a marked forward angle in the upper part which accentuates the apparent shortening.

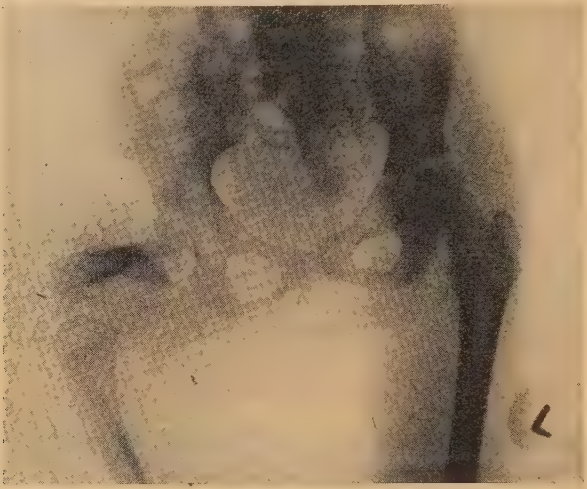


FIG. 83.—Congenital absence of upper half of femur

Congenital absence of fibula

Suppression of one of the two intermediate segments is more common than phocomelia; the commonest example is congenital absence of the fibula (see Fig. 84). The fibula is rudimentary or absent, the tibia is short and has a forward angulation at the junction of the middle and lower thirds, and over the summit of this bend there is a dimple in the skin; the foot is held in equino-valgus, and the fifth and fourth toes may be missing. The whole forms a characteristic picture.

By persistent and repeated orthopaedic measures the foot can be made plantigrade; but as the child grows the affected leg becomes shorter than the other, until when adult life is reached the degree of shortness renders an amputation and the replacement of the leg by an artificial limb the best procedure.

Congenital absence of the radius, ulna or tibia also occurs, but less frequently.

Congenital pseudarthrosis of tibia

Another important although rare type of suppression is congenital pseudarthrosis of the tibia. In this condition there is, at the junction of the middle and lower thirds of the tibia, an area of disordered osteogenic activity where the bone is weak or even absent. Soon after birth a fracture may occur at this site. The resulting weak union leads to an angulation of the tibia when the child attempts to take weight on the leg. The importance of the condition is that the angulation is liable to be mistaken for a rickety deformity, and an osteotomy or an osteoclasis may be done to correct the alignment; such an osteotomy will be followed by a pseudarthrosis, which resists all attempts to obtain union. On the few occasions that union has occurred after massive grafting the leg has remained short.

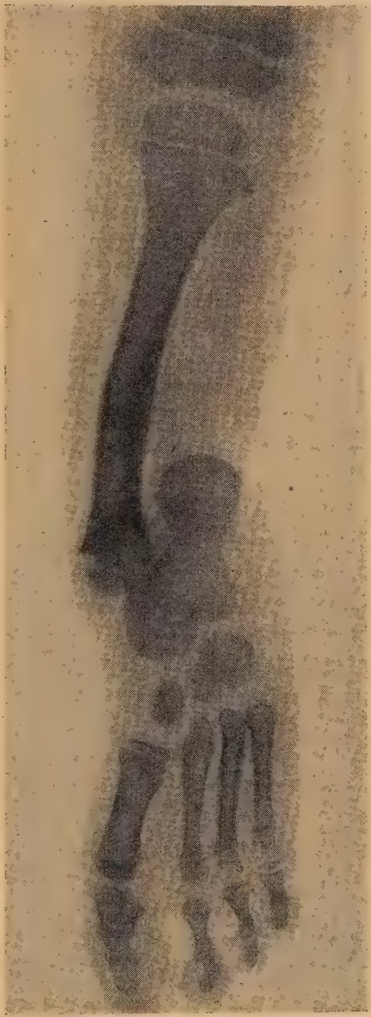


FIG. 84.—Congenital absence of fibula

Hypertrophy of limb buds

True hypertrophy of the limb buds may involve the whole of one limb, or may be confined to one segment. The commonest variety affects only one terminal segment, either a finger or a toe. Overgrowth of the limb may occur in association with diffuse overgrowth and enlargement of the blood-vessels.

Supernumerary segments

Supernumerary transverse segments are very rare, with the exception of an additional phalanx to the thumb. Additional longitudinal segments are not uncommon, e.g. polydactyly. The accessory digit is usually rudimentary and springs from the outer side of the foot or from the thumb; as it is unsightly and useless it is best removed.

Fusion of segments

Rarely, there is fusion between the root segment and the intermediate segment; more commonly one of the intermediate segments is fused with its fellow, e.g. radio-ulnar synostosis (see below); most common of all, two of the terminal segments are fused together, e.g. syndactyly (see below).

Radio-ulnar synostosis

Radio-ulnar synostosis is a congenital anomaly due to partial fusion of one intermediate segment of the limb bud with its fellow. The upper inch or so of the radius is fused by bone with the upper part of the ulna. The forearm (see Fig. 85) may be curved from bending of the radius if the radius is growing faster than the ulna. Movement at the elbow is unimpaired but no rotation of the forearm is possible. On a casual examination it is hard to convince oneself that the radius and the ulna move as one bone, because rotatory movements take place at the shoulder and at the carpus; rotation at the carpal joints is much greater than normal. The disability is not incompatible with the earning of a livelihood; in fact some cases are not diagnosed until adult life. No attempt should be made to divide the synostosis; the operation invariably fails in its object because not only are the two bones united proximally by bone, but they are also connected throughout their length by unstretchable fibrous tissue; moreover, the patient lacks muscles with which to rotate the forearm even were it possible to separate the two bones.

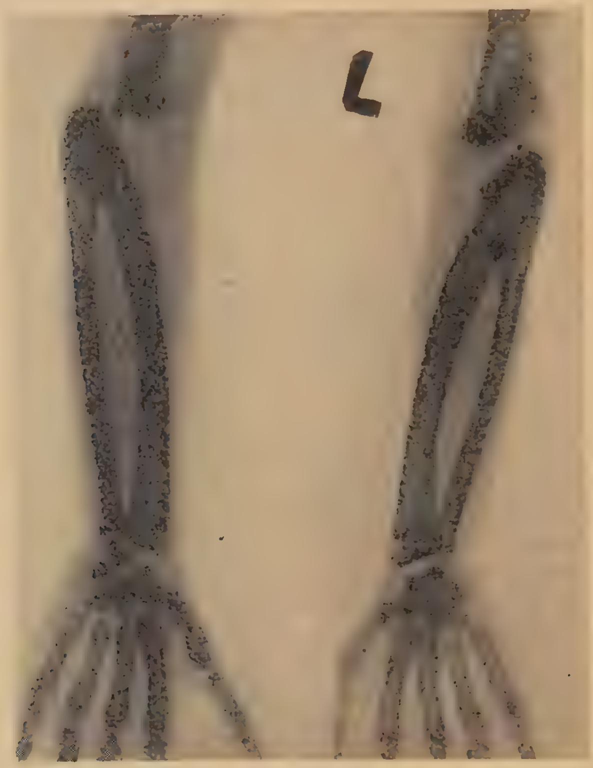


FIG. 85.—Congenital radio-ulnar synostosis

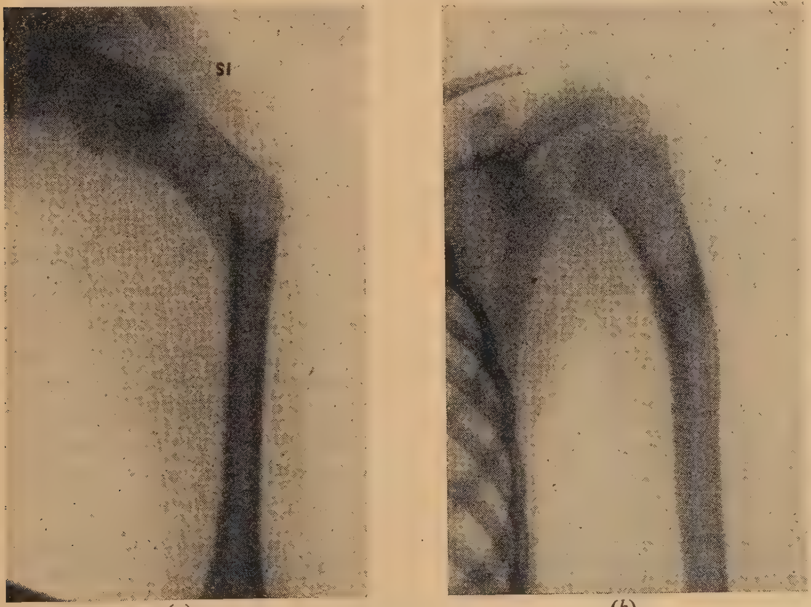
Syndactyly ('web fingers')

Syndactyly ('web fingers') may be either congenital or acquired. The acquired form follows severe burns if there has been destruction of the tissues of the fingers and subsequent fusion of the granulating surfaces. Two varieties of the congenital form may be recognized: the primary, due to suppression of segmentation (see p. 558); and the secondary, due to amniotic adhesions. In the latter, the first and fifth fingers are usually joined together; both fingers possess the ordinary number of bones, the bones are often overlapped, and the fusion is between the terminal part of the fingers. This variety is not hereditary. In the primary variety, which is much commoner, either the second finger is joined to the third, or the third to the fourth, or all three are connected; the thumb and the little finger are rarely involved. The bones are not overlapped and may themselves be fused. The tips of the fingers usually remain separate; it never happens that the tips of the fingers are joined and the proximal parts separate. This variety is often hereditary. Treatment is difficult and not always desirable. Excellent function is possible even when four fingers are fused, and their separation is called for more for cosmetic reasons than for the improvement of function. The difficulties in treatment lie in forming a commissure, and in covering over the raw areas after the separation of the fingers. The patient should be placed under the care of a plastic surgeon.

3.–FIBROCYSTIC DISEASE OF BONE (OSTEITIS FIBROSA)

Classification

177.] Fibrocystic disease is the name given to a miscellaneous group in which there is a lacunar absorption of bone by osteoblasts, and replacement of the normal bone by (1) a cyst, or (2) an osteoclastoma, or (3) a mass of fibrous tissue, or (4) a mixture of irregular bone and fibrous tissue. The process may be confined to one part of the bone, or extend over the whole of one bone, or involve all the bones in the body. The generalized form is associated with disordered calcium-phosphorus metabolism; the aetiology of the other forms is unknown. From this



(*a*) (*b*)

FIG. 86.—Solitary bone cyst. (*a*) Fracture through cyst. (*b*) Same bone but cyst obliterated with union of fracture

group certain clinical entities may be isolated: (1) Solitary bone cyst (see below). (2) Osteoclastoma; Benign giant-celled tumour (see p. 566). (3) Diffuse fibrosis of bone (see Fig. 87). (4) Generalized osteitis fibrosa (see PARATHYROID GLAND DISEASES).

Solitary bone cyst

Solitary bone cyst is a circumscribed affection of bone limited to one part of one bone, in which there is lacunar absorption of bone by osteoblasts and the replacement of the normal bone by a cyst. The aetiology is unknown, and calcium and phosphorus metabolism are normal. The cyst is diagnosed by the radiogram. Microscopically the apparent cystic area may be either a cavity filled with clear or cloudy sterile fluid, or it may be a solid tumour, which cuts like a turnip and consists of fibrous tissue with areas of haemorrhage. In these areas giant cells may be numerous so that in a limited field the tissue may be indistinguishable from osteoclastoma. The cyst may appear in one of the long pipe-bones or in one of the short pipe-bones; it does not occur in the flat bones.

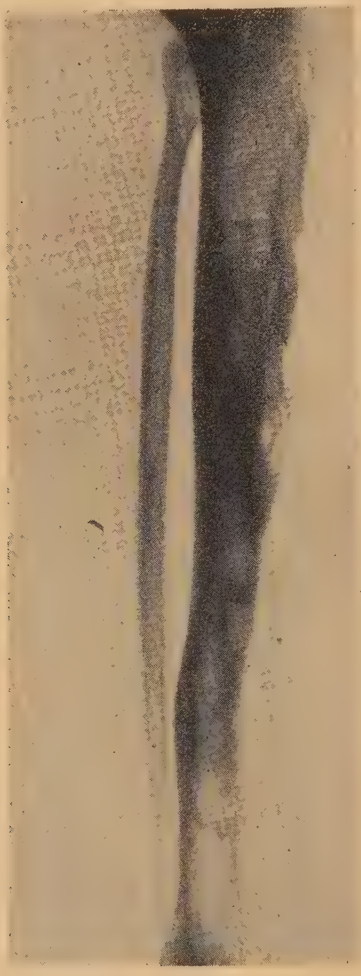


FIG. 87.—Diffuse fibrosis of bone

In the long pipe-bones

In the long pipe-bones the site is constant. The cyst begins in relation to the unossified part of the metaphysis close to the epiphysis. Subsequent growth at the epiphysis may shift the area involved further up the shaft but it is always located within an inch or so of the epiphysial line. The upper ends of the femur, humerus and tibia are the commonest sites, in that order. The patients are usually below the age of eighteen, the average age being between ten and fifteen. The cyst is clinically silent until the bone fractures through the weakened area; rarely the neighbouring joint is irritated and the patient complains of a limp. There is no pain. The diagnosis is revealed by the X-ray picture, and is usually unsuspected. The X-ray (see Fig. 86) shows a translucent area, the size of a chestnut at least, more or less circular and symmetrically placed in the metaphysis near the epiphysial line. There is no surrounding bone sclerosis or reactionary subperiostial new-bone formation; and the cortex remains, although it may be thin. The remainder of the bone is of normal shape and texture. As a rule the bone is fractured through the cystic area. The age of the patient, the absence of symptoms, the site of the cyst and the X-ray appearance render the diagnosis easy. Often, with the healing of the fracture the cyst is obliterated (see Fig. 86) and it seems wise in cases of fracture to wait and see whether this will be the outcome. Spontaneous disappearance of the cyst probably occurs in the course of time, as the condition is rare in the adult—so rare that when suspected the diagnosis is probably wrong. It is difficult to know whether or not a cyst discovered accidentally should be operated upon. Nothing can be lost by waiting, but if the cyst appears to be increasing in size operation is indicated. The cavity should be curetted until healthy bone is reached, and the cavity then swabbed out with a caustic, such as pure carbolic, and finally washed out with alcohol. The cavity may then be filled with a bone graft, but this course is seldom necessary. It is possible that the trauma inflicted by the surgeon to the bone is sufficient to stimulate the deposition of bone and the obliteration of the cavity.

Treatment

In the small pipe-bones

Solitary cysts occur in the metacarpals, metatarsals, and the proximal phalanges. In age incidence, site, clinical history, and discovery by X-ray examination following trivial injury, solitary cysts in the small pipe-bones do not differ from those in the long pipe-bones. But because it is difficult to differentiate a simple cyst from an enchondroma, which in the bone of the hand is just as common, and because enchondromas, although usually benign, may undergo malignant change, it is advisable to operate on all cystic areas in the bones of the hands and feet (see Fig. 88).

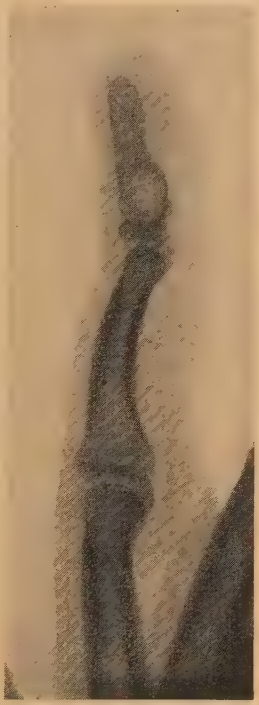


FIG. 88.—Solitary bone cyst in terminal phalanx

For hydatids in bone, see the article on HYDATID DISEASE.

4.–OSTEITIS DEFORMANS (PAGET'S DISEASE)

Morbid changes in the bones

178.] Osteitis deformans is a clinical entity in which there is progressive enlargement, bending and structural change of the bony skeleton. Pathologically, three phases may be described, which may all be present simultaneously either in the same bone or in different bone of the body. Phase 1: Destruction and removal of normal bone by osteoblasts, and its replacement by vascular connective tissue. Phase 2: Deposition of new bone, in a disorderly fashion, by metaplasia of the connective tissue.

Phase 3: Cessation of bone destruction and intense ossification, so that the connective tissue is all replaced by dense sclerotic bone.

Aetiology

Its cause is unknown. It has no connexion with abnormal calcium and phosphorus metabolism, and does not interfere with the other organs of the body or influence the general health of the patient. The pathological process is similar to that in fibrocystic disease. Cysts and osteoclastomas are not found in osteitis deformans, but otherwise it may be difficult to distinguish between the two conditions microscopically. Clinically, however, fibrocystic disease and osteitis deformans are rarely confused with one another. Osteitis deformans is rarely diagnosed in a patient under the age of thirty—the majority are much older—but this gives no indication of the age of onset of the disease as it may exist for some years without revealing its presence clinically. Women are more commonly affected than men.

Clinical picture

Two types are met with: (1) the generalized more common form, in which every bone is affected to some extent, and (2) the localized form, in which only one bone—usually the tibia—is affected. In the localized form one can trace the affection spreading slowly up the shaft of the bone in X-ray photographs taken at yearly intervals. When one bone in an extremity is obviously affected, routine X-rays may show earlier but characteristic changes in the pelvis. The localized form may occur in the pelvis.

The symptoms in the generalized form are: (1) Bone pain. This is almost certainly due to the bending of the bone under the influence of body-weight; it is relieved by rest. In the X-ray pictures one can often see transverse linear cracks indicating partial fractures extending halfway or more across the bone. (2) Deformity. This is most marked in the bones subjected to the weight of the body—i.e. the vertebral column, the femur and tibia. (3) Bone enlargement. The skull is nearly always enlarged, a fact to which the patient's attention may be drawn by the discovery that he has to take a larger size in hats. The cranial cavity is not diminished in size because the cranial contents are sufficiently resistant to the softened bone, but the foramina at the base of the skull may become occluded, causing, by pressure on the cranial nerves, progressive deafness and even optic atrophy. The pituitary fossa is not enlarged. The facial appearance is altered by the expansion of the forehead.

The back rapidly acquires the appearance of an extreme degree of senile kyphosis, and in the last stages the chin touches the sternum. The calibre of the spinal canal may be diminished and cases of insidious paraplegia, from compression of the cord, have been described. The bones of the upper limb do not show much change externally. In the lower limb the femur is curved forward, and the normal curve of the tibia forwards and outwards is likewise greatly intensified. This, with the flexed spine, gives a simian attitude to the patient. Fractures are uncommon, but when they occur they unite with great rapidity. In the radiogram the long bones of the lower limb are thicker and bent. The cortex is much widened and encroaches on the medulla; its margins are irregular and the regular bone lamellar structure is replaced by a homogeneous mass of varying density (see Fig. 89). At a late stage the cortex may show dense sclerosis. The pelvis (see Plate VIII, B) is usually affected and its delicate pattern of bone lamellae is replaced by coarse trabeculation. Radiologically the skull shows no differentiation into inner and outer tables, but instead an irregular alteration of sclerosed and rarefied areas.

Differential diagnosis

The diagnosis is confirmed on the X-ray appearances. Bending of the long bones may occur also in generalized osteitis fibrosa and in osteomalacia, but in neither condition is there a general increase in the width of the bones. The late stages of osteitis deformans may suggest chronic osteomyelitis, but at no stage of the latter is the bone soft, and therefore bending does not occur. The combination of thickening and angulation is pathognomonic of osteitis deformans.

Prognosis

The disease is slowly progressive over a number of years and probably few patients live long enough to exhibit the final stage of dense bone sclerosis. The disease does not influence the general health or expectation of life of the patient with this exception, that osteogenic sarcoma may sometimes develop in the affected bone. Various estimates have been made of the frequency of this complication. Some authorities have placed it as high as 10 per cent, others deny its existence. Koloday has stated that 5 per cent of the cases of osteogenic sarcoma recorded in the Register of the American College of Surgeons have arisen in Paget's disease. It seems probable that malignant disease does not, in fact, occur in more than 1 or 2 per cent of cases of Paget's disease of bone.

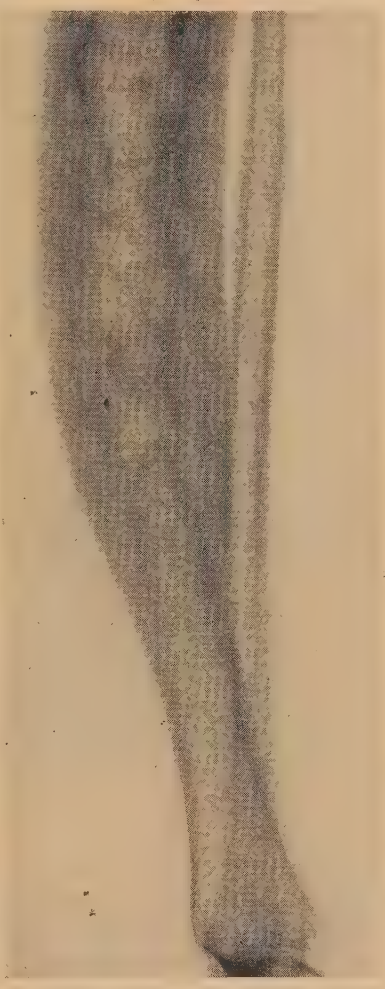


FIG. 89.—Osteitis deformans. Upper half of tibia only affected

Treatment of Paget's disease

There is no prophylactic or curative treatment known for this affection. Osteotomy of the tibia, to correct the ugly bow-leg appearance, is an operation of great value, for it also abolishes pain, provided that the tibia is set straight and that further angulation is thus prevented. It is the continual bending strain on the bone that gives rise to the pain, but once the bone is straightened it remains straight and such bending strain is removed. Ultra-violet rays have been recommended, and in some cases the pain has been eased by this treatment and the X-rays have shown evidence of bone regeneration. The treatment must be continued several times a week for many months. The worst feature of the disease is the crippling pain in the back for which there is little or no remedy. A back brace is rarely of any value because the spine has already flexed too much for it to be effective as a support. (The treatment is further discussed in the article on BACKACHE, p. 254.)

Leontiasis ossea

Leontiasis ossea is the name given by Virchow to a rare condition in which there is hypertrophy of bone localized clinically to the facial and cranial bones. It is probable that this is only a localized form of osteitis deformans, for radiograms of the other bones show the characteristic appearances of this affection. The enlargement of the head, which is the first sign, begins about puberty; and the later enlargement of the facial bones gives to the face a leonine appearance. Like osteitis deformans the affection has no influence on the general health of the patient, although pressure effects within the skull may cause headaches, deafness, and optic atrophy.

5.–OSTEOCLASTOMA (NON-MALIGNANT GIANT-CELLED TUMOUR; 'MYELOID SARCOMA')

179.] These are the names given to a tumour of bone which forms a definite clinical entity, but which under the microscope may be indistinguishable from the solitary cyst of bone, diffuse osteitis fibrosa, or osteitis deformans. Macroscopically the tumour, which occupies the end of a long bone and has a peculiar consistency like liver, is homogeneous, fairly circumscribed and maroon in colour. It oozes blood like a sponge when pressed upon. Fibrous intersections extend into the interior from a fairly well-defined capsule. Microscopically the distinguishing feature is the presence of large giant cells, with an abundant cytoplasm, and numerous nuclei of small uniform size and arranged in a whorl. The giant cells are embedded in a groundwork of connective-tissue cells and small round cells. Vessels are numerous and old haemorrhages and cystic areas are also present. From an examination of a section the expert pathologist is able to state whether the tumour is indolent or active or has malignant tendencies.

Morbid anatomy

The tumours occur in the skeleton and also extra-skeletally in association with tendon sheaths and the periosteum of the maxilla (epulis). The sites of election in the skeleton are the extreme ends of the long bones—i.e. the upper end of the tibia, lower end of the femur, lower end of the radius, and head of the fibula, in that order of frequency. They may also occur, but more rarely, in the bodies of the vertebrae and in the flat bones, particularly of the pelvis.

Symptoms

The symptoms are the insidious onset of discomfort—hardly pain—of two to twelve months' duration, followed by the enlargement of the bone in the neighbourhood of the joint. In about 10 per cent of cases spontaneous fracture first draws attention to the tumour. On examination of the limb, one finds a club-like enlargement of the end of a bone, tapering to the normal shaft. The enlargement is asymmetrical, smooth and painless. The overlying soft parts, the skin, and the neighbouring joint are normal. At a later stage the veins appear prominent over the swelling and there may be some fluid in the neighbouring joint. Egg-shell crackling, though now quite rare, does sometimes occur. The X-ray (see Fig. 90) reveals a normal bone except at its extremity; here there is an area of rarefaction, large and asymmetrically placed, with clearly-defined margins, and no sclerosis of the surrounding bone. The area extends to the cortex on one side and usually is bordered on another side by the cartilage covering the end of the bone. The tumour never penetrates the joint cartilage and rarely breaks through the cortex, which, however, may be expanded over it. There is no periosteal reaction outside the cortex. The site of the tumour and its X-ray appearance are characteristic and the diagnosis is rarely in doubt. The patients are young adults.

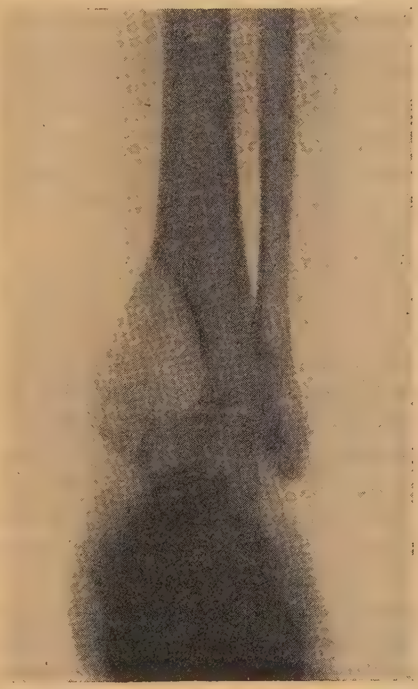


FIG. 90.—Benign giant-celled tumour. Lower end of tibia

The nature of this clearly-defined clinical entity is doubtful. Whether it is inflammatory or traumatic in origin or due to a distortion of the normal process of formation of bone from cartilage is of little interest to the clinician, because the swelling behaves like a neoplasm and must be treated as such. It is locally invasive and destructive, but undoubtedly benign, except in a few very rare, but authentic, cases in which secondary tumours of a similar microscopic appearance have occurred and caused the death of the patient.

Treatment of osteoclastoma

The neoplastic tissue area must be eradicated completely and as soon as possible. In the majority of cases it is possible to do this by curetting thoroughly the walls of the bone cavity after removal of the contents. This as far as possible should be done under guidance of the eye. Any tumour cells left adhering to the wall of the cavity are killed with pure carbolic acid, which is then washed out of the cavity with alcohol. Some surgeons favour obliterating the cavity by a bone graft; this however is seldom necessary. The dangers of the operation are haemorrhage and infection, and if a graft is used the latter danger is increased. The tumour recurs in 20 per cent of cases. If the tumour cannot be eradicated by curettage a portion of the bone may be resected; recurrence is then less likely. This operation is not of much value in the lower limb because it leaves a flail joint and the patient is no better off than if the limb had been amputated. In recurrent cases amputation may, in fact, be the best treatment; it has the advantage that recurrence is avoided with certainty. Of late, X-ray and radium therapy have been tried with success, but it is too early yet to say that they will supersede operative treatment. There is a similar divergence of opinion on the therapeutic value of radium and X-ray after the tumour has been removed surgically; some maintain that it increases the risk of infection and prevents the cavity from filling with bone, others that it does lessen the likelihood of recurrences.

X-ray and radium therapy

6.–ACUTE OSTEOMYELITIS

Pathogenesis

180.] Acute osteomyelitis is an haematogenous pyogenic infection occurring usually in children; it is rare after twenty. Boys are affected more commonly than girls. The disease is not common; indeed, a large general hospital may not admit more than one patient a month with acute osteomyelitis. The causal organism is in three-quarters of the cases *Staphylococcus aureus*, although other organisms may be responsible. The bacteria probably gain entrance into the body through the skin, usually from a septic sore, or by way of the throat, and pass into the blood-stream, which they leave to settle in some area of diminished resistance. There may be direct infection of the bone in an open fracture. The usual site of election is the metaphysis of a long bone; occasionally the disease arises in the diaphysis, or in the flat bones, or in the body of a vertebra. Rarely there are multiple foci, but in such cases the patients usually succumb quickly to the general infection, and clinically most patients present only one focus of acute inflammation as a primary lesion.

In the ordinary form of the disease—at the metaphysis of a long bone—the commonest situations are the upper end of the tibia, the lower end of the femur, and the lower end of the tibia. Occasionally the upper end of the femur and the lower end of the radius are attacked.

Morbid changes in the bones

In the centre of the inflammatory area pus is soon formed, and tries to find a way out of the bone. The direction that the pus takes is of considerable importance. It passes out through the Haversian canals into the subperiosteal space, and then advances along the shaft, separating the periosteum from the cortex and shutting off the blood-supply derived by the cortex from the periosteum. Finally it bursts through the periosteum at one point and infiltrates the soft tissues. As it spreads under the periosteum it may re-enter the bone through other Haversian canals and set up secondary areas of infection throughout the shaft. The pus does not, however, tend to extend up the medulla from the original focus, nor does it easily infect the joint, for the joint capsule is but rarely penetrated, and in my experience the growth disc never; though it is stated that penetration of the growth disc does very exceptionally occur. Acute inflammation in bone differs from acute inflammation elsewhere in producing early and massive death of tissue. The blood-supply to the cortex is cut off by tension of the exudate, and the vascular engorgement and the stripping up of the periosteum, and the isolated area of bone thus deprived of blood dies. Massive necrosis is the rule, but it can be rendered minimal by an early operation designed to relieve the tension of the pent-up pus and carried out in such a way as not to strip the periosteum from the cortex. In few diseases are early diagnosis and prompt treatment so well repaid. The necrosed bone in course of time separates from the living bone as a sequestrum, or rather as sequestra, for usually there are many; and these are encased in an involucrum, a shell of new bone which has been laid down on the deep aspect of the stripped-up periosteum. So long as the sequestra remain they cause persistent irritation and a continuous discharge which makes its way to the skin and escapes through a small sinus. This channel remains open until all the sequestra have been extruded along its track or have been removed by the surgeon. It can be readily understood that when there has been widespread inflammation of a bone with the formation of a large number of small sequestra in its depths, sinuses are likely to persist in spite of many sequestrectomies.

Diagnosis

Good treatment is impossible without prompt diagnosis. Acute osteomyelitis should be suspected in any child who, after a mild trauma, develops pain near an epiphysial line. Platt has divided the disease into three phases—prodromal, early, and late; and it should be the endeavour always to make the diagnosis in the first of these. The infection is then still localized to the metaphysis, and the pus has not as yet reached the surface of the cortex. The patient complains of pain at the end of one of the long bones, and this pain is constant in site and intensity. The child limps. There is tenderness over a small area of the metaphysis, which, from its size, is known as 'finger point tenderness'. There is no swelling and no redness of the skin, the neighbouring joint moves freely, and the X-ray picture is normal; but the child is obviously ill and there is fever and malaise out of proportion to the local trouble. In the next or early phase, the pus has reached the surface of the cortex and is subperiosteal. Fixed pain and localized tenderness are more evident. There is now an enlargement of the bone, and fluid in the neighbouring joint; usually the limb is too painful to move, much less bear weight. In both the prodromal and the early phases signs of general infection are present. The face is flushed, the tongue dry and furred, and the patient drowsy (until one touches the tender bone); the temperature reaches 100° F. or higher, and the pulse-rate is 120 or more. A leucocytosis is present. If the patient does not die of toxaemia and the condition remains undiagnosed, the late phase is reached. Now, in addition to the previous signs, there may be redness of the skin, oedema and even fluctuation. The X-ray picture is still negative, and does not reveal anything until about the tenth day. The diagnosis is often overlooked because the doctor considers it to be 'rheumatism' and the mother 'growing pains'. Acute monarticular rheumatism never occurs; moreover, the tenderness in polyarticular rheumatism is situated over the joint rather than over the metaphysis of the bone. An acute arthritis (for example, of the hip) may be difficult to distinguish from acute osteomyelitis until after the joint has been aspirated. Finger-tip tenderness of bone is present with a fracture, but the absence of general symptoms and the positive X-ray picture render the differential diagnosis easy.

Prognosis

The disease has a high immediate mortality, which varies directly with the virulence of the infection and probably not at all with the efficacy of local treatment. Death occurs within the first week in 10 to 25 per cent of cases; these are the acute pyaemic cases with secondary abscesses in the viscera and elsewhere. The subsequent function of the limb depends on the promptness and efficacy of local treatment as well as on the virulence of the infection. It is not possible to tell at the time of operation how much bone will die. Multiple sequestrectomies may later be necessary and a sinus may persist for years. On the rare occasions in which the joint is involved the usual sequel is ankylosis. There is always a likelihood of interference with growth at the epiphysis; often the limb is longer or shorter than its fellow and growth may be so irregular that a joint deformity develops (e.g. genu valgum and pes valgus are common). Sometimes the whole of the shaft is sequestrated leaving only the epiphysis at either end. In such circumstances a new shaft is usually laid down by the stripped periosteum, but a gap may exist in the middle of the shaft and non-union may be permanent.

Treatment of acute osteomyelitis

Treatment is divided into immediate and subsequent. Immediate treatment is directed to two ends—combating the general infection and restricting the amount of bone necrosis. The general treatment is that common to all infections. It is doubtful whether serum therapy, intravenous disinfectants or blood transfusions are of any value. The principles underlying the local treatment are simple—namely, to drain the focus as early as possible, and to do so without devitalizing any more bone or spreading the infection into non-infected areas. Three methods of drainage are employed:

Drainage

(i) Subperiosteal and metaphysial. An incision is made over the area of finger-point tenderness, down to the periosteum. If pus is encountered under the periosteum nothing further is necessary. If no pus is encountered the metaphysis is opened by drilling the cortex in several places, or by cutting out a small trephine opening. As soon as pus is reached the surgeon has done sufficient. A curette should not be used, otherwise the cancellous tissue preventing the spread of the infection in the medulla may be removed. The periosteum should not be stripped up from the cortex, for the more this is done the more will the blood-supply of the cortex be interfered with. A drainage tube or a light paraffin pack is left in contact with the cortex, and the skin is left unsutured.

(ii) Diaphysial. In this method the medulla is widely opened by guttering the cortex over a large area. A weighty argument against the use of this method is that it exposes a large previously uninfected area and does not lessen (but on the contrary increases) the amount of bone necrosis.

(iii) Drainage by diaphysectomy. In this method, the whole affected portion of the shaft of the bone is removed by subperiosteal resection. It is the most effective method of drainage and it removes all bone which might subsequently prove to be dead; but if the periosteum has been damaged a new shaft may fail to regenerate and shortening or non-union may result. In patients not seen until the late phase—i.e. when the whole of the shaft has been involved by secondary areas of infection—this method of treatment has its value. With early diagnosis and prompt treatment it should never be necessary.

Removal of sequestra

Subsequent treatment is required to remove sequestra (see Fig. 91) which are too large to be extruded through the cloacae in the involucrum. Operation for this purpose should not be undertaken until the necrotic bone has been separated from the living bone. It is often difficult to be sure that there is a sequestrum, and if there is, whether its size is such that it cannot be extruded unaided. The radiogram is the deciding factor; dead non-vascular bone is much denser than living vascular bone. If such a sequestrum appears to be in the interior of the bone surgery will probably be necessary for its removal; if it appears to lie outside the bone, it will probably be extruded without the surgeon's aid. Probing a sinus rarely gives any useful information. The sinus certainly goes down to bone, but the probe cannot assist in the decision whether the bone it touches is alive or dead. If the bone appears loose to the probe, it is usually free enough to be extruded unaided. Irregular growth at the epiphysis may call at a later day for osteotomy to correct deformity. A late consequence of acute osteomyelitis is the formation of pyaemic abscesses, which may appear in any part of the body; they need only incision and evacuation. These procedures (including evacuation of pus, debris and sequestra) are sufficient even when the secondary foci occur in bone, as they frequently do.

Acute epiphysitis of infants

The occurrence of acute osteomyelitis in the flat bones and in the bodies of the vertebrae is uncommon and the mortality rate is higher. The upper end of the femur is sometimes the site of infection, and in young children the condition appears clinically as a primary acute arthritis. The reason is that in them the epiphysis of the femur lies within the hip-joint with the result that the pus drains into the joint itself. The condition is called acute epiphysitis of infants and frequently leads to destruction of the head of the femur and pathological dislocation of the hip-joint. These children, if they survive, present a difficult problem.

The hip-joint is dislocated, the limb tends to acquire a flexion adduction deformity, and growth at the upper end of the femur is retarded.

7.–CHRONIC OSTEOMYELITIS

181.] This may be considered under three headings:

(i) The sequel to an acute osteomyelitis.
(ii) Of insidious onset and localized.
(iii) Of insidious onset and diffuse.

Sequel to acute osteomyelitis

(i) The sequel to acute osteomyelitis. If, as usually happens, the original focus of infection in the metaphysis has spread, forming many secondary areas of infection half-way or more up the shaft of the bone, there will remain minute sequestra and scattered small areas containing living organisms. These, for the most part, are enclosed in fibrous tissue, and being rendered inert and harmless do not call attention to their presence. But the sequestra, especially if large, may irritate the surrounding living tissues which react by the exudation of serum that tends to wash the dead material away. This serum makes its way to the surface forming a permanent sinus. Also, the organisms may, as it were, mutiny against the surrounding guard of fibrous tissue, and produce an acute inflammation. The cellular tissue around the bone may also, in a similar manner, become acutely inflamed.

Thus, after the healing of the incision at the primary operation during the acute attack, or of the incision made subsequently for the removal of sequestra, the bone may remain quiescent for many years. Or a permanent sinus may be present, causing little disability but necessitating daily dressings to prevent soiling of clothes. Or the bone, after a quiescent period of perhaps many years, may become inflamed again. The patient complains of pain in the bone; the bone is tender, the limb becomes hot, the soft tissues may be acutely inflamed, and usually (though not invariably) general signs of an acute infection are present. But although the temperature and the pulse-rate may be high, the general signs of toxaemia are never so prominent as at the time of the original infection; in fact, in spite of a high temperature the patient may even appear normal except for loss of appetite and slight malaise. Occasionally, the acute inflammation spreads from the cellular tissues to the deep layers of the skin, and a condition may develop almost indistinguishable from erysipelas, but without its accompanying signs of intense toxaemia. The patient usually applies for treatment for a persistent sinus or for the recurrence of an acute inflammation.

Treatment

For a persistent sinus surgery is the only treatment, but should not be lightly undertaken. If the X-ray shows a well-defined sequestrum, or if it seems feasible to excise the whole of the diseased area of bone, surgery is indicated, but not otherwise. It is useless to explore a sinus leading down to a very large area of chronic osteomyelitis without removing the cause of the sinus. Many patients with chronic osteomyelitis as the result of an infected gunshot wound have undergone twenty or more operations without permanent benefit. If, after due thought, operation is decided upon, the sinus should be explored and the sequestra to which it leads should be removed; if no sequestrum is found, as much infected bone as possible is removed and the resulting bone cavity converted into a saucer by bevelling its bony walls. Gauze soaked in paraffin is then lightly packed into the saucer and the wound left open. This gauze should not be changed, but as the saucer wound gradually heals from the bottom, it will be slowly extruded. Winnett Orr lays stress on the advantage of immobilizing the limb in plaster of Paris after the operation and of putting a covering over the dressing. Probably the important part of this much vaunted method of treatment is the non-interference with the gauze pack. The discharge from the wound creates a disgusting stench, which from the point of view of the patient and his friends is the objectionable part of the treatment.

No non-surgical treatment will aid a sinus to heal. On the other hand, continuous packing of a sinus with gauze, or constant probing or syringeing, will cause the persistence of a sinus which otherwise would heal. There is no advantage in trying to keep a sinus patent; for if there is purulent material to be got rid of, the sinus will remain open, and if nothing is passing along the track it will heal.

FIG. 91.—Chronic osteomyelitis of tibia, the sequel of acute osteomyelitis. The remainder of the cortex is seen as a sequestrum

Recurrence of acute inflammation

For recurrence of acute inflammation, masterly inactivity is usually the most successful method of treatment. Provided the limb is kept at rest the acute inflammation settles in a few days. Intense bone pain and the persistence of a high temperature lasting more than three days indicate that the recent inflammation has probably resulted in the formation of an abscess, the contents of which cannot find their way to the skin through any existing sinus. Operation may then be necessary, but it should be confined to giving an exit to the pus; as soon as pus is reached the object of surgical interference has been realized. An extensive bone operation only increases the area of bone devitalization and the likelihood of greater sequestration. Patients with chronic osteomyelitis are familiar with these 'flares' or bursts of renewed acute inflammation. The bone begins to ache and to feel warm, and often they can avert an attack by resting the limb when the prodromal feelings of aching in the bone and increased warmth of the limb warn them that an attack is pending. It is difficult to see how vaccine treatment can help. At each flare the patient must receive a large dose of autogenous vaccine; but this does not render him immune from another flare.

Localized type of insidious onset (Brodie's abscess)

(ii) Chronic osteomyelitis of insidious onset, localized to a single area of bone. With a mild acute infection, or a chronic infection, there may develop in bone an area of inflammation which remains clinically silent until an abscess of some size has developed. This is usually diagnosed by the radiogram, which shows a small translucent area, the size of a walnut or larger, surrounded by a margin of dense bone. This may appear anywhere in the bone; the metaphysis is the commonest site, but, as the abscess may remain undiscovered for some years, the area involved may be some distance from the growth disc owing to the increase in the length of the shaft. Almost any organism may be responsible, the staphylococcus and tubercle bacillus being the commonest. A characteristic alternation of acute exacerbations and remissions of pain in a bone, especially at night, draws attention to the condition. There may be local tenderness of the bone and the bone may be thickened. If the area is near the epiphysis, there may be an effusion into the neighbouring joint and an X-ray picture shows the lesion to be in the bone.

Differential diagnosis

Differential diagnosis is difficult. The site of the lesion usually excludes the possibility of simple bone cyst and giant-celled tumour, for the latter is always at the extremity of the bone, and the former in the metaphysis; but if a translucent area in the metaphysis is a bone abscess, the fact that the area of translucency always seems in the X-ray (see Fig. 92) to have pierced the growth disc, rules out the simple bone cyst. The nature of the infection can only be guessed at unless there is a bacteriological investigation of the pus: a dense margin of sclerosed bone around the abscess suggests syphilis (see Fig. 96); rarefied surrounding bone, the tubercle bacillus (see Fig. 94), and normal surrounding bone, a mild pyogenic infection (see Fig. 92).

Treatment

The abscess cavity should be explored, its contents evacuated, and the cavity washed out with a disinfectant. The wound may then be closed. It is unnecessary to bevel the cavity walls or to drain.

Generalized type of insidious onset

(iii) Chronic osteomyelitis, of insidious onset, widely spread throughout the bone (sclerosing non-suppurative osteomyelitis). Garrè gave a classical description of this condition and it is often known by his name. The diagnosis is made on the X-ray appearance (see Fig. 93) which shows a fusiform widening of the cortex of a long bone on its superficial and deep aspects.

Morbid changes

The medullary canal, although narrowed, always persists, thereby distinguishing the condition from the sclerosing type of osteogenic sarcoma. The trabeculation of the widened cortex has a normal architecture. The tibia and the femur are the bones usually affected. There may be infiltration of the overlying soft parts (especially in the thigh), and a corresponding limitation of movement at the neighbouring joint. The patient complains of constant pain in the bone, which he can feel to be enlarged. The pain is worst at night. That the condition is inflammatory is probable, because there may be some pyrexia and in a few cases suppuration occurs later in spite of the name of the disease. The condition is rare; so too is the type of osteogenic sarcoma with which it is liable to be confused. In osteitis deformans the architecture of the bone is always altered, and in chronic osteomyelitis due to syphilis the uniformity of the bone is spoilt by mottled areas corresponding to areas of gummatous degeneration. Nevertheless the condition should not be diagnosed unless the Wassermann reaction is negative. If the pain is severe some relief may be obtained by guttering the bone or more simply by drilling a series of holes into the medulla.

Differential diagnosis

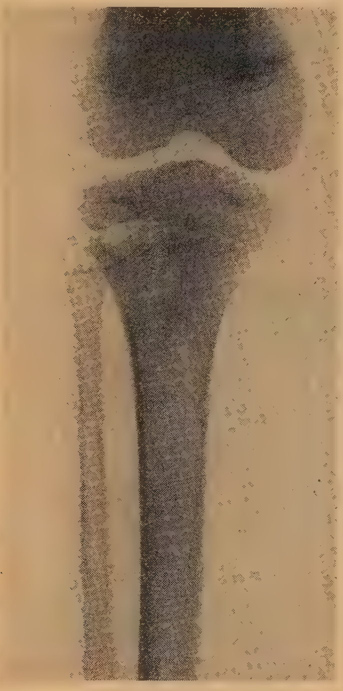


FIG. 92.—Localized chronic osteomyelitis (staphylococcal) in upper end of tibia. Compare with Fig. 94

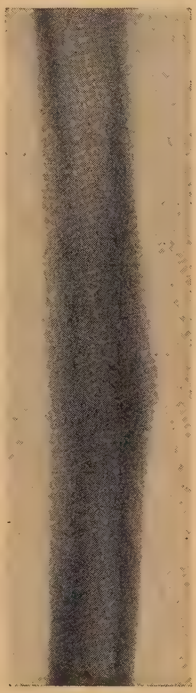


FIG. 93.—Garrè's chronic osteomyelitis of femur

A subacute form of osteitis which may occur as a late sequel to typhoid fever is described under the title ENTERIC FEVER.

8.–TUBERCULOUS DISEASE OF BONE

182.] This takes the form of a localized circumscribed chronic inflammation in bone. The sites commonly chosen are: (1) the metaphysis of a long bone (see Fig. 94); (2) the shaft of a small pipe-bone (see Fig. 95); (3) the body of a vertebra; and occasionally (4) a rib or other flat bone.

Usually only one site in one bone is attacked. If the disease is spread throughout a long bone in many places there is, in addition, infection of the soft parts and several sinuses, and often secondary infection. Occasionally in children multiple localized areas of infection are present in different bones—corresponding to the metastatic abscess formation common in pyogenic infections. The lesion in each particular area is benign, and heals as soon as the caseous material finds a way to the surface.

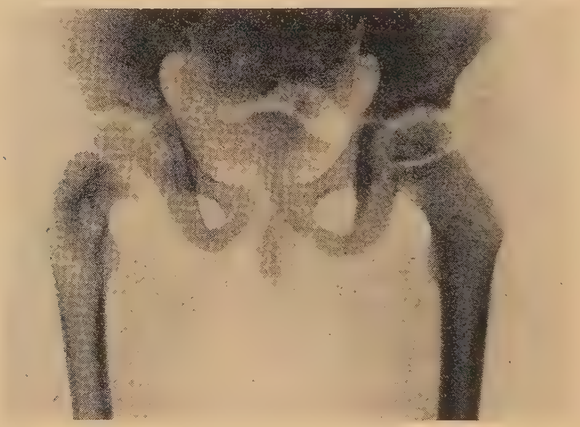


FIG. 94.—Localized chronic osteomyelitis (tuberculous) in upper end of femur. Compare with Fig. 92 .

It is important to realize that tuberculous infection of bone is silent clinically until the occurrence of one or other of the following events:

(1) Signs of irritation of the neighbouring joint, if the site of infection is near the end of a long bone.

(2) Signs of bone compression and destruction (i.e. a kyphos, if the site of infection is in the body of a vertebra).

(3) A cold abscess making its way towards the surface and presenting itself under the skin, if the site of infection is in the ribs or shaft of a bone away from a joint.

The inflammation in the bone rarely attracts attention by pain, as does the chronic pyogenic infection of bone. It follows that diagnosis is difficult, and radiography is not helpful until sufficient caseation has occurred in the centre of the infected area to show an area of bone absorption. This local rarefaction may be caused by chronic inflammation due to other organisms (staphyloccocal, pyogenic, syphilitic). But around the clear area caused by a pyogenic infection there is no sclerosis of the bone margin and the bone outside has a normal density; in syphilitic infection there is a sclerosed margin and the bone around is rather denser than usual; and in tuberculous infections there is no sclerosed margin but the rest of the surrounding bone shows intense atrophy.

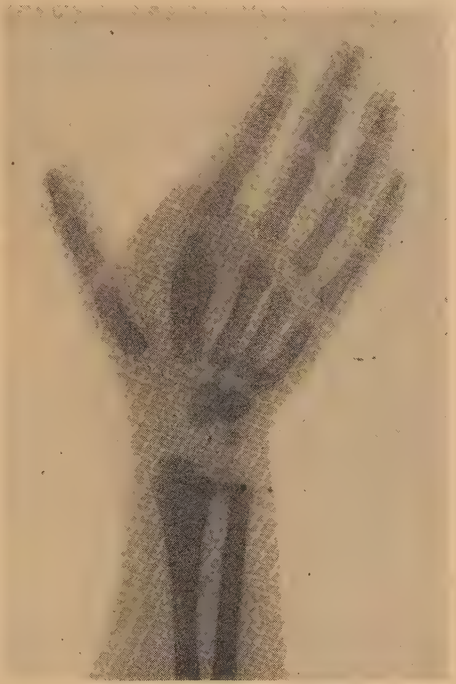


FIG. 95.—Tuberculous dactylitis

Treatment

Treatment should be directed towards (*a*) the general infection, and (*b*) the local infected area. The general treatment differs in no way from that of tuberculosis elsewhere in the body. The local treatment is complicated by secondary considerations — for example, destruction and collapse of the bodies of the vertebrae in tuberculosis of the spine, or involvement of the joints in tuberculosis of the long bones. Disease in these areas is considered under separate headings (see SPINE, and JOINTS, DISEASES AND DISORDERS). Where such considerations do not arise—i.e. where there is no joint involvement and the bone as a whole is not destroyed—the principles of treatment are simple: to excise an area of bone which will include the infected area, or, if that is impossible, to evacuate the caseous material and remove all weight and strain from the bone by rest. Excision is possible, for example, in tuberculosis of a rib, whereas excision of the diseased area in tuberculous dactylitis would destroy the integrity of the phalanx or metacarpal. Caseous material may be removed by aspiration, but considerable skill is required to remove the thick caseous lumps, and frequently the caseous contents of the cold abscess have first to be liquefied by the injection of a liquefying fluid. Repeated aspirations will be necessary, and even so a sinus may develop. It is often better to plan an open operation, incise the abscess wall, remove the entire contents and close the skin incision afterwards. No attempt should be made to curette the walls of a sinus or of an abscess, the sole object of the operation being to remove the contents of the abscess. Secondary infection is reputed to be the bugbear of this operation but experience has shown that secondary infection does not, as is supposed, follow the evacuation of a cold abscess by open incision and immediate closure of the skin wound. Evacuation of the caseous material is usually followed by healing of the local bone infection. If the primary single area of infection has spread and many areas of infection have appeared throughout the bone, the prognosis is poor as regards local healing, and usually the patient's life can be saved only by amputation, if the site of the lesion permits.

9.–SYPHILITIC DISEASE OF BONE

183.] This is nowadays uncommon. It takes the form of either (*a*) localized gummata, occurring under the periosteum or in the medulla, or (*b*) diffuse gummatous osteomyelitis.

Subperiosteal gumma

Subperiosteal gumma is the commonest form. It may arise:

(1) In the skull, sternum or ribs, forming an area of bone rarefaction surrounded by a margin of dense sclerosis, visible in the X-ray picture. Corresponding to this area there is a firm, slightly tender lump with a softened centre, which can be felt beneath the skin.

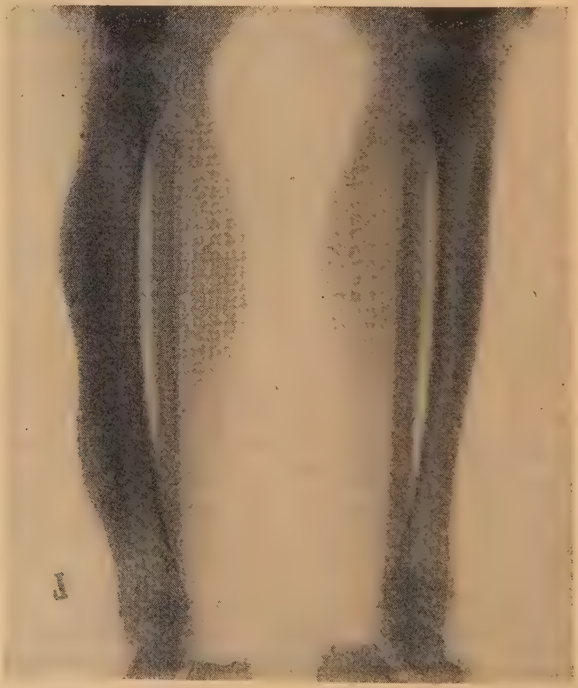


FIG. 96.—Syphilitic osteomyelitis

(2) In the long bones, particularly the tibia (see Fig. 96). Here it appears

as a localized fusiform, firm and slightly tender swelling of the shaft of the bone. The swelling makes it appear that the bone is bent. The X-ray shows the swelling to be a diffuse periostitis, in the centre of which is a superficial oblong area of rarefaction. Clinically the patient may complain of the swelling, or of deep boring pain, worse at night in bed.

Cancellous gumma

Cancellous gumma occurs in the shaft of a long or short pipe-bone. When the lesion is small, indefinite pain may lead to the taking of an X-ray (see Fig. 97), which shows a small area of localized rarefaction with a dense bony margin, and perhaps some periostitis. It is difficult to differentiate this from a similar area of rarefaction caused by a pyogenic or tuberculous infection. If the condition remains undiagnosed, the gumma may increase in size and erode the cortex; new periosteal bone is laid down on the outside as the cortex is worn away, and the appearance of an osteolytic bone sarcoma may be simulated. Antisyphilitic treatment will often cause the 'tumour' to disappear. The enlargement of the bone or a spontaneous fracture may bring the patient to the doctor. It is rash to diagnose a bone sarcoma if the Wassermann reaction is positive.

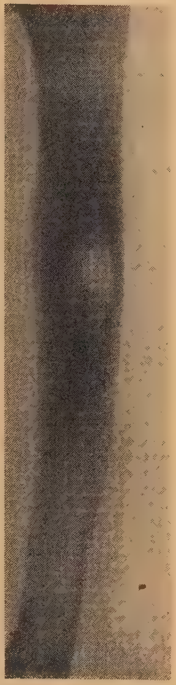


FIG. 97.
Cancellous gumma

Diffuse gummatous osteomyelitis

Occasionally there is diffuse endosteal and periosteal thickening of a long bone—diffuse osteomyelitis—without any localized rarefaction. The patient complains of intense bone pain. The diagnosis is made on the results attending antisyphilitic treatment. The X-ray picture sometimes has to be differentiated from that of a chronic pyogenic osteomyelitis or a late stage of osteitis deformans.

Congenital syphilis

All the above types are seen also in patients with congenital syphilis. The subperiosteal node occurs most commonly in the tibia, where it may be confused with rickety bending of the bone, and in the skull (Parrot's nodes). The cancellous gumma occurs at the metaphysis in infants of three months, and is often multiple, appearing simultaneously in several bones. Sudden pseudoparalysis draws attention to the limb, and the end of bone in the neighbourhood of the epiphysis is found to be enlarged and tender. In young children, cancellous gummata are found in the shafts of the metacarpals and the phalanges, and have to be differentiated from the much commoner form of dactylitis due to tuberculosis. The multiplicity of the lesions, the presence of periostitis elsewhere in the body, the Wassermann reaction and the results of treatment leave no doubt about the diagnosis.

The form in which there is diffuse thickening of periosteum and endosteum also occurs in children, usually in the tibia.

All forms of bone syphilis quickly respond to general antisyphilitic treatment—an important differential point in any doubtful case.

10.–TUMOURS OF BONE

(1)—Non-malignant

Osteo-chondroma

184.] Excluding osteitis fibrosa cystica and giant-celled tumour (see pp. 561 and 566) there are only two benign bone tumours—osteochondroma and chondroma.

Osteochondroma is a bony outgrowth from some part of the skeleton, covered with a cartilaginous cap undergoing calcification or ossification. It springs from the neighbourhood of the metaphysis of a long bone, at the site of a tendon attachment, or from the surface of a flat bone (e.g. the pelvis or scapula). The tumour may be single or there may be several arising from different bones. The patients are usually between the ages of 10 and 25 when they come under notice. Two types are met with: (1) exostosis (cancellous osteoma) (see Fig. 98) and (2) osteochondroma proper (see Fig. 99).

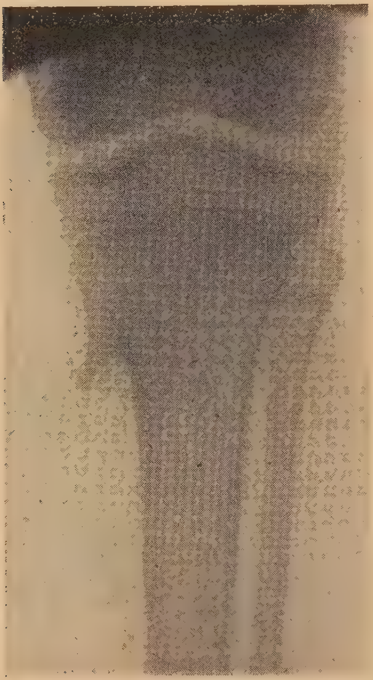


FIG. 98.—Exostosis, or cancellous osteoma

Exostosis

Exostosis forms a conical tumour. The base springs directly from the cortex of the underlying bone, is well defined and not very broad. The cap is pointed and projects in a slanting direction away from the neighbouring joint; it is covered with a thin layer of cartilage. The tumour rarely gives rise to symptoms; occasionally it may interfere with the free action of a tendon, sometimes a bursa develops over its apex and becomes inflamed, and rarely it presses on a nerve. It can be felt clinically, and the X-ray reveals its innocent nature. In dyschondroplasia (see p. 556) multiple tumours of this type may be present. Usually the tumour, after slowly increasing in size while the patient is still growing, ceases to enlarge further and gives rise to no disability. This type of osteochondroma never undergoes malignant change. Should treatment be considered necessary the tumour should be removed by cutting through its base, and any portion of tendon attached to the apex should be sacrificed. If this is done recurrence is extremely unlikely.

Osteochondroma proper

Osteochondroma proper (see Fig. 99) forms an irregular craggy mass. The base is broad and indefinite, but springs directly from the underlying bone, like the exostosis. It projects away from the bone in no definite direction and is capped by a large calcifying cauliflower-like mass, which has a smooth lobulated surface. The overlying structures are not attached to the tumour except perhaps at one point, corresponding to a tendon attachment. The tumour is, in fact, only an exaggeration of the normal bony protuberance for the anchoring of an important tendon. The tumour from its size may interfere with the neighbouring joint, but otherwise gives rise to no symptoms. The patient seeks advice because of the lump, which may be very big; it is firm, not tender, attached to bone, and the overlying structures move freely over it. It is usually larger than the X-ray suggests, as a considerable part of the cap is cartilaginous. This type of osteochondroma should be excised if possible because about 7 per cent become malignant after the age of 40. Often, however, the position renders its removal difficult. Deep X-ray therapy will usually cause the whole tumour to calcify, and will destroy the potentially malignant cartilage-cells on the surface of the cap. Signs suggestive of malignancy are onset of pain and a rapid increase in growth of a tumour which for years has remained stationary in size. The actual size of the tumour is no indication of its malignancy.

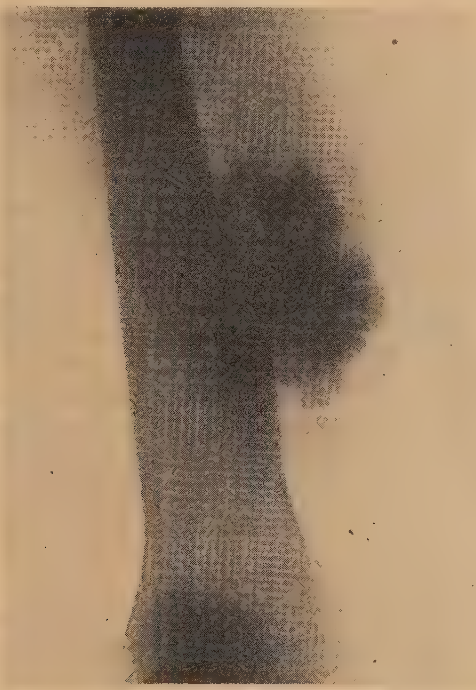


FIG. 99.—Osteochondroma

Chondroma (chondro-myxoma)

Chondroma (chondro-myxoma) is an endosteal tumour occurring usually in the small bones of the hands (see Plate VII, B) and feet, occasionally in ribs and vertebrae, and rarely in the shaft of a long bone (see Fig. 100). Multiple tumours occur in about 5 per cent of cases, and almost invariably in those that occur in the hands and feet. The X-ray shows an area of rarefaction in the centre of the shaft, within a shell of cortex which is often thin and expanded. Isolated specks of calcification can usually be seen. The remainder of the bone is of normal density and there is no periosteal reaction. In the small bones the condition is almost indistinguishable from a simple cyst, and in the long bones the diagnosis is made only after exploration, and microscopical examination of the tissue removed. Unless there is obvious swelling, the presence of the tumour is as a rule unsuspected until an X-ray examination is made to exclude injury to bone following trauma. A fracture through the site of the tumour after a mild trauma occurs in 10 per cent of cases. When diagnosed the tumour should be excised if possible as the tendency to malignancy, especially in the long bones, is considerable. Local curettage is usually sufficient.

FIG. 100.—Chondroma in the head of the radius

(2)—Malignant

Malignant tumours of bone may be divided into those of osseous origin, i.e. related to osteogenesis, and those of non-osseous origin. The osseous tumours are: (1) chondro-sarcoma; (2) osteolytic osteogenic sarcoma; and (3) osteoblastic osteogenic sarcoma. The non-osseous tumours are: (1) Ewing's sarcoma; (2) multiple myeloma; (3) parosteal sarcoma; and (4) metastatic carcinoma.

Chondro-sarcoma

Chondro-sarcoma is a malignant tumour derived from the pre-cartilaginous connective tissue, which forms a bond of union and a growth zone between the ends of a tendon and the normal roughened area on the surface of a bone from which the tendon springs. It is the malignant counterpart to the benign osteochondroma. The common sites are the tibia and the femur near the knee-joint (about two-thirds of the cases), and the pelvis and scapula. The condition is rare before puberty and after the age of thirty. The patient gives a history of a few months of increasing pain. The bone close to the joint is enlarged. The joint may be flexed, and immobile on account of pain. The inguinal glands are normal as metatases in glands do not occur. Macroscopically the tumour appears as a fusiform swelling under a raised perforated periosteum; it is pearly grey and shiny, and on section reveals cystic areas embedded in cartilage. The underlying cortex may not be eroded although lobules extend up and down and around the shaft. Microscopically the tumour is composed of dense embryonic connective tissue with myxomatous areas and foetal and adult cartilage cells. Only occasional patches of bone are present. It is often difficult to distinguish the tumour from a benign chondroma. The tumour is often called the invisible bone tumour, because in the X-ray only a faint translucent shadow outside the shaft of the bone can be seen. The cortex and medulla of the bone are normal. Periosteal lipping may be present, i.e. a small triangular area of bone on the cortex at either end of the tumour where the periosteum begins to be separated from the underlying bone by the tumour. Sometimes fine spicules of calcification radiating at right angles to the shaft are seen. The tumour appears in the X-ray to be smaller than one would expect from the clinical examination. The differential diagnosis has to be made from a benign osteochondroma. Myositis ossificans has a definite edge and laminated bone parallel to the shaft, and is related to a recent trauma. The benign osteochondroma casts a much denser shadow, has a more definite margin and its base is ossified.

Prognosis

The prognosis is grave; death from metastases usually occurs within twenty months of the first symptom. Only one patient in twenty will survive the five-year period. Amputation should be performed to relieve the pain, but as recurrence rarely takes place in the stump, the site of election may be chosen; there is no advantage in amputating very high up in the limb.

Osteogenic sarcoma

Osteogenic sarcoma is a malignant tumour derived from cells which are the ancestors of osteoblasts. According to whether the osteoblasts are from the osteogenic layer of the periosteum or from the osteogenic layer of the endosteum, they give rise to tumours differing in shape, consistency and rate of spread, and with separate and distinctive physical signs, so that clinically the two types are distinguished as osteoblastic and osteolytic.

Osteoblastic osteogenic sarcoma

Osteoblastic osteogenic sarcoma is a malignant tumour derived from cells which are the ancestors of osteoblasts, lying in the osteogenic layer of the periosteum. It is the one bone sarcoma easily recognized in the X-ray and on that account, and because its treatment is usually undertaken early, it has a slightly better prognosis than the other form. The usual age-incidence is between 15 and 25; 80 per cent appear about the knee-joint. The tumour arises at the metaphysis and is subperiosteal. It spreads rapidly up and down and around the shaft, under the periosteum. The bone cortex is slowly eroded, but the periosteum itself is resistant and restrains the tumour for a while. As soon as the periosteum is perforated (e.g. by the surgeon) the spread is rapid. The skin is resistant, and usually is destroyed by the pressure of the tumour rather than by infiltration. Death as a rule occurs before the skin becomes ulcerated. The patient complains of pain and of a lump. There is a visible and palpable swelling near the end of the bone, the neighbouring joint moves freely, the skin is normal, but enlargement of the superficial veins may be a very suggestive sign, and there is little or no loss of function. The patient appears to be in perfect health, although later when secondary growths are present there may be pyrexia and a leucocytosis. The X-ray is characteristic. In the early stage the cortex and medulla of the bone are normal, but outside the shaft are fine radiating lines of new bone running out at right angles to the shaft. Later, the medulla is obliterated by a mass of dense new bone and the cortex remains just visible. Outside the cortex the spicules of bone at right angles to the shaft now form a continuous mass. Macroscopically the bulk of the tumour is between the periosteum and the cortex; on section the superficial parts are gritty and the deeper parts bony. Microscopically the tumour consists of spindle cells, osteoblasts and osteoid tissue and bone. Only occasionally are cartilage cells seen, and there is no myxomatous tissue and no foetal cartilage. The prognosis is grave, but relatively good for a bone sarcoma. If not dead within eighteen months of the onset of symptoms, the patient will probably survive; about 25 per cent survive the five-year period. As soon as the tumour is diagnosed the limb should be amputated at the site of election above the mass.

Osteolytic osteogenic sarcoma

Osteolytic osteogenic sarcoma is a malignant tumour derived from cells which are the ancestors of osteoblasts, lying in the osteogenic layer of the endosteum. Cancellous bone is normally formed via calcified cartilage but as calcified cartilage is absent at the place and time when these tumours arise ossification is incomplete and very little new bone is formed. The tumour is therefore osteolytic, as compared with that derived from the subperiosteal osteoblasts which is osteoblastic. The usual age-incidence is between 10 and 25 but the incidence falls gradually after the age of 20. The femur and the tibia are most commonly affected. The tumour may arise from any part of the bone; it begins in the medulla and spreads very rapidly up and down the interior of the shaft. The cortex is slowly eroded from within and the bone then breaks. Spontaneous fractures occur in half the cases. The patient complains of severe pain and inability to use the limb. Swelling is not an early sign; it indicates that the tumour has penetrated outside the shaft. So soon as this happens spread is very rapid, and there is a visible, palpable and pulsating swelling, which almost seems to fluctuate. The skin over the lump is tense and hot; the veins are enlarged. The X-ray (see Plate VII, C and D) is difficult to interpret. There is destruction of bone of the medulla; the cortex is thinned or may have apparently melted away; new bone is laid down on the outside by the periosteum but as this is constantly being eroded the bone appears to be expanded. The tumour is very vascular and hence is sometimes called an 'aneurysm of bone'. Microscopically the tumour consists of embryonic connective-tissue cells and small round abortive osteoblasts with a few malignant giant cells. A small amount of osteoid tissue is present and large blood spaces without endothelial lining. There is no cartilage or myxomatous tissue. The prognosis is very grave. Most patients die within a year of the first symptoms. Only 6 per cent survive for the five-year period. Immediate amputation makes the patient comfortable, but death from metastases quickly follows. Neither irradiation nor the administration of Coley's fluid appears to increase the chance of survival.

Ewing's sarcoma

Ewing's sarcoma is, at any rate in England, a rare tumour which differs from osteogenic sarcoma clinically, radiographically and microscopically. Its pathogenesis is doubtful. It is extremely rare after the age of 20. The tumour chooses the middle of the shaft of one of the long bones, and arises within the cortex. Intermittent attacks of pain draw attention to the limb which may be swollen, the swelling suggesting a periostitis. Fracture is rare. The average duration of symptoms is twelve months; this contrasts with an average of three or four months in the case of an osteogenic sarcoma. The swelling sometimes is tender, and there may be a slight pyrexia. The condition thus simulates osteomyelitis, and the resemblance is heightened by the X-ray appearance. The medulla may be encroached on by the cortex which is thickened and the normal texture of the cortex is replaced by parallel coarse bony trabeculae, resembling onion peel. Macroscopically the bulk of the tumour lies between the periosteum and the cortex. Microscopically the cells are mostly small round cells; there are no giant cells, cartilage or osteoid tissue. The prognosis is better than in osteogenic sarcoma, about 16 per cent surviving the five-year period. The tumour rapidly disappears under X-ray or radium irradiation, but it recurs, and is then resistant to radiation. Amputation is therefore the better method of treatment. Metastases occur most commonly in the lungs, but unlike other bone tumours may also appear in the lymph glands.

Multiple myeloma

Multiple myeloma is a rare malignant endosteal tumour of bone, arising from haemopoietic cells. The age-incidence is between 40 and 60. The patient when he comes under observation has multiple tumours, scattered throughout the ribs, sternum, the bodies of the vertebrae and the long bones, i.e. wherever there is red marrow. The long bones are never attacked alone. The symptoms are vague. Pain, particularly referred from the back, or a fracture, usually calls attention to the condition, and it is diagnosed on the X-ray appearance. All the bones affected exhibit multiple punched-out areas in the medulla in varying size from a pea to a marble. The rest of the bone appears normal. Microscopically the prevalent cell looks like a plasma cell. All the patients die, usually within two years, from cachexia or anaemia.

Parosteal sarcoma

Parosteal sarcoma is not truly a bone tumour, but a fibro-spindle-celled sarcoma arising from the outer layers of the periosteum and the adjacent soft parts, and invading bone secondarily. It forms a smooth, rather hard swelling attached to the bone, but the X-ray shows the bone to be intact. Clinically the lump may be confused with a gumma. The tumour is not very malignant and can usually be excised locally, or treated by X-rays or radium.

Metastatic carcinoma

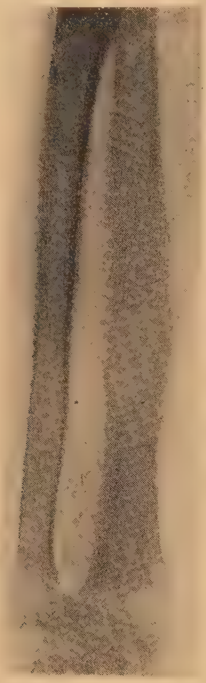


FIG. 101.
Secondary carcinoma in shaft of radius

Metastases in bone are frequent in hypernephroma, and in carcinoma of the lung, prostate, testis and breast, in that order. Primary neuroblastomas of the adrenal medulla (Hutchison type) are specially prone to cause metastases in the skull, whereas malignant tumours of the adrenal cortex rarely do so. The renal 'hypernephromas' (Grawitz tumours, clear-celled carcinomas of the kidney), however, often give rise to bony metastases which may pulsate. Growths composed of thyroid tissue secondary to latent primary carcinomas of the thyroid, the so-called 'benign metastasizing goitre', are relatively common in the skull, vertebrae, and other bones (Simpson), and may also pulsate and imitate aneurysm.

Often the primary focus is not discovered during life. Usually the first sign is a spontaneous fracture through the shaft of a long bone. The X-ray (see Fig. 101) shows that the fracture has taken place through a globular area of rarefaction in the centre of the shaft. The bone above and below is normal and there is no periosteal reaction. The age of the patient alone distinguishes the X-ray appearance from a simple cyst. The rate of growth is not great and often the fracture will unite. Sometimes X-ray or radium therapy will prevent further increase in size, and will often allay pain.

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BORNHOLM DISEASE

By Sir HUMPHRY ROLLESTON, Bt., G.C.V.O., K.C.B.

(*Synonyms.*—Epidemic myalgia; acute epidemic myositis.)

Definition

185.] This disease, first reported in this country under the place name in 1933 by Pickles, had previously been described in 1872 in Norway, in North America in 1888, and under various names, such as epidemic transient diaphragmatic spasm, epidemic pleurodynia, and acute muscular rheumatism. Sylvest, who observed an outbreak in the Danish island of Bornholm, referred to ten thousand cases in Denmark since 1930.

Aetiology

It occurs chiefly in the late summer months, attacks the sexes equally, those under the age of puberty being more liable; it spreads by direct contact, and has a short incubation period of two to four days. The responsible virus has not been discovered.

Clinical picture

Clinically it appears to be the counterpart, in front of the trunk, of lumbago; pain, which is specially associated with respiration, may be felt in the back as well as in front as high up as the pectoralis major muscles. The onset may be very sudden with pain, most commonly in the upper abdomen; slight fever is almost constant, headache frequent, and hiccough is occasionally troublesome; but vomiting is rare. The muscles are tender, painful on contraction, sometimes palpably swollen and the superficial abdominal reflexes may be absent. Orchitis may supervene. The disease may imitate an acute abdominal emergency, and laparotomy for probable appendicitis has been performed.

Course and prognosis

It runs its course in about a week. The prognosis is good, the few recorded deaths being due to complications, such as pneumonia or angina pectoris. As regards immunity it resembles influenza.

Treatment

Treatment is symptomatic; for the relief of pain morphine has been necessary.

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BOTULISM

By W. M. SCOTT, M.D.
Medical Officer of the Ministry of Health

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Reference may also be made to the following title:
FOOD POISONING

186.] Botulism may be defined as the disease produced by ingestion of the toxin elaborated by the growth in food materials of *Clostridium botulinum*, an anaerobic spore-bearing bacillus, the natural habitat of which is the soil. *Definition*

1.–AETIOLOGY

Preserved food The food most likely to cause the disease, judging from American and the small British experience, is some form of canned or potted vegetable, or, less often, meat which has been eaten without cooking. In America canned ripe olives, spinach and runner beans have been the commonest causes. Potted meat paste (wild duck) was responsible for the fatal Loch Maree outbreak of 1922 fully described by Leighton, and 'vegetable brawn' for the London outbreak of 1935.

Uncooked meat On the Continent of Europe, especially in Germany, sausage and smoked ham have been the commonest sources, both being eaten raw after storage. But it is probable that almost any food in which the necessary conditions of temperature, moisture and anaerobiosis are present may, if infected with botulinus spores, become dangerous if ingested without further cooking. The toxin is destroyed by heat so that well-cooked food, eaten at once, can usually be regarded as innocent.

2.–PATHOLOGY AND BACTERIOLOGY

Morbid anatomy

Post mortem, the morbid anatomy and histology are seldom characteristic, although neuron destruction and inflammatory perivascular reactions have been said to occur. Cultures from the intestines, spleen and liver not infrequently reveal the presence of the specific bacillus or of its spores.

Bacteriology

Briefly the morphological and cultural characters of *Cl. botulinum* are as follows: The bacillus is a Gram-positive straight rod with rounded ends and from 4 to 6μ in length. It shows slow motility and possesses 20 to 30 lateral flagella. It commonly forms subterminal oval spores with distension of the rod, but terminal spores with little distension are found with some strains, especially of type C. Growth is fairly strictly anaerobic and takes place in all the ordinary media. The types A and B are proteolytic but C is not: all strains ferment glucose and certain other sugars (with gas production) but not lactose or sucrose. Growth in protein-containing media produces a rather characteristic rancid but not putrefactive odour. The important biological features of the bacillus from a practical standpoint are (1) the high resistance to heat displayed by its spores (2 hours of moist heat at 100° C.), and (2) the potency of the toxin elaborated in both animal and vegetable matter by its growth. The optimum temperature for toxin production is 37° C., and little toxin is formed by growth below 20° C., even after several months. The minimum lethal dose for a guinea-pig of a fully developed toxic culture may be less than $\frac{1}{100}$ of a milligram and approximately proportional doses have caused death on ingestion by man. The toxin is unaffected by digestion (peptic and tryptic), but is destroyed by heat in 5 minutes at 80° C. and by alcohol (20 per cent) in 10 minutes at 37° C. Three types of *Cl. botulinum*, A, B, and C, have been described, the toxin of each type being completely neutralizable by its own antitoxin alone. Of these, type A produces the majority of the fatal human cases; type B is less toxic but can produce fatal botulism: no type C botulism has so far been described in the human subject.

Toxicology

The work of Edmunds indicates strongly that the action of the toxin is not, like that of tetanus, directly on the neurons but on the motor nerve-endings of voluntary muscle, i.e. it resembles that of curare, with, in addition, a less pronounced attack on the nerve-endings of the parasympathetic system. The importance of this fact, as affecting the line of treatment to be adopted, is obvious.

3.–CLINICAL PICTURE

Earliest symptoms

The subjective symptoms are, in order of frequency and in sequence of appearance, blurring of vision and dizziness; these usually appear within twenty-four hours of ingestion of the toxin and are almost certainly both due to partial paralysis of the oculomotor muscles, the dizziness being due to the consequent disturbance of the vestibulo-ocular reflex. Diplopia, photophobia and lachrymation follow rapidly in more than half the cases. Difficulty in speech with dryness and a sense of constriction in the throat and, in a minority of cases, inability to swallow may appear within thirty-six hours. The inability to swallow leads to accumulation in the throat of thick and tenacious mucus which increases the difficulty in speech and hampers respiration. Headache occurs in about half the cases in the early stages. Nausea and vomiting may occur early, but only in a minority of cases. Abdominal cramps are an occasional but rare symptom. Obstinate constipation is characteristic, being observed in all but the mildest cases. Vomiting, diarrhoea and severe abdominal pain are absent. The urinary function is unaffected except in the final stages of a fatal case. The temperature and pulse-rate remain normal until the death agony. A feeling of extreme muscular weakness may appear early and is almost invariably present by the fourth or fifth day even in mild intoxications. The mental faculties and the special senses (except vision) remain unaffected to the end; there may be insomnia, in part due to fear; drowsiness is rare.

Early symptoms

In the later stages of the illness dyspnoea is the most distressing symptom; it is chiefly due to the progressive weakening of the general musculature affecting the respiratory muscles.

Late symptoms

On inspection, the pale mask-like face with drooping eyelids, forcing the patient to prop the lid with his fingers in order to see, is characteristic when the disease has passed the earliest stage. Some degree of ptosis of both eyelids will be found early in about 30 per cent of all cases. It is associated with divergent squint and with occasional spasms of the paretic internal rectus. Accommodation is difficult. The fundus oculi shows venous congestion but the optic disc is unaltered. The eye signs indicate partial paralysis of the third cranial nerve together with a retinitis, presumably toxic. Signs in the mouth and pharynx are much less evident. Apart from the tenacious mucus above-mentioned, the only observations likely to be made are the apparent difficulty in protruding fully the tongue, and perhaps relaxation of the palate with drooping of the uvula.

Objective signs

Except in the last stages of fatal botulism, no objective signs are found in the other systems; the heart and lungs, the glandular system and the abdomen are all normal; the blood-pressure is within normal limits and there is no alteration in the count and cytological formula of the blood. The urine may be scanty owing to difficulty in swallowing fluid, but seldom shows other alteration.

The extremities in about 80 per cent of cases show definite muscular weakness and the weakness of the neck muscles may be so great that the head falls back as the body is raised, a sign often found in acute poliomyelitis. There is, however, none of the muscular tenderness characteristic of that disease.

Special neurological examination reveals, in addition to the signs already mentioned, that there is no true ataxy, the staggering gait so

Nervous system

characteristic of the early stages of botulism being due to oculo-vestibular disturbance combined with muscular weakness. Rombergism is absent. There are no tremors, choreiform or athetoid muscular contractions. The earliest disturbance of speech is a difficulty with the 'th' sound, probably due to weakness of the tongue muscles. In the later stages aphonia may be complete owing to paresis of the pharyngeal and laryngeal muscles; paralysis of one or both vocal cords may persist long after convalescence. There are no sensory disturbances. Examination of the functions of the oculomotor nerves often shows differences on successive days; the most common weakness is in convergence, but bilateral ptosis is almost equally common. Mydriasis occurs in about a third of the patients who eventually recover; there may be complete loss of the light reflex and it is usually sluggish. Accommodation is usually difficult but rarely completely absent. The sensory functions of the fifth cranial nerve are intact. There is general muscular weakness beginning in the neck, arms and legs, but no fibrillary tremors: in fatal cases paralysis may be complete.

Reflexes

The conjunctival, palatal, umbilical, plantar, biceps, triceps, patellar, and Achilles reflexes are all practically normal; Kernig's sign is absent.

Abdominal tympanites may be present in the later stages and is almost certainly due to intestinal atony, to which also the obstinate constipation is due. There are no trophic disturbances.

4.–PROGNOSIS

The earlier the symptoms appear, the more severe as a rule is the intoxication and the more grave the prognosis. But there are many exceptions to this rule and fatal cases may fail to show symptoms for as long as four days after eating infected food; the importance of treating

Mortality

all consumers of such food without delay is obvious. The case mortality varies in different outbreaks from nil to 100 per cent. This wide range is chiefly due to the difference in the amounts of toxin present in the ingested food. There is, however, some evidence that intoxication due

Type of infection

to the A type of the botulinus bacillus is more fatal than that due to B and still more so than that due to C, so that early determination of the type involved in a particular outbreak may aid the prognosis. No outbreak due to B or C has been identified in Britain.

5.–DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Epidemiological investigation, with the most thorough and careful inquiry into food shared by other people, should, of course, form part of the diagnostic procedure when botulism is suspected. Not only will it establish the identity of the disease by the detection of the contaminated food and its submission to laboratory tests, but also it will discover other possible victims who have not yet had symptoms, and whose lives may be saved by the timely administration of antitoxin.

Bacteriological examinations

The laboratory is the final court of appeal in suspected botulism and no pains should be spared in collecting specimens of suspected food for laboratory tests. Even an empty tin retrieved from the dust-bin may provide sufficient material to establish the diagnosis. In general, if the toxic food is found, animal tests will demonstrate the presence of the specific toxin within thirty-six to forty-eight hours. The faeces and vomit should also be examined, since the spores of botulinus can be found in the alimentary canal for at least several days and can be identified by suitable culture and animal inoculation.

Proof of botulism in an individual patient or in an outbreak depends on the demonstration either of the bacillus itself or of its specific toxin in the suspected food material. In the absence of such demonstration, the detection of the bacillus in the excreta of the patient or in his body post mortem would constitute strong corroborative evidence of clinical suspicion.

Clinical diagnosis

Clinical diagnosis is difficult in an isolated case since the symptoms and objective signs may resemble closely those of a case of epidemic encephalitis of the type in which paresis of the medullary nerve-centres predominates. Most of the authentic cases of botulism have revealed themselves to the clinician by occurring simultaneously, or nearly so, in groups of people who have shared food.

Diagnosis from epidemic encephalitis

Real difficulty may be met in the differentiation of an isolated case of botulism from a case of epidemic encephalitis. In both, paralysis of the muscles supplied by cranial nerves occurs and the general aspect of the sufferer is very similar. When cases occur in groups, the history of a common meal points strongly to botulism. A group of cases of epidemic encephalitis, on the other hand, need not have a common alimentary factor; moreover, there will usually be among them a much greater variation in the symptoms and course of the disease; they will be inclined to somnolence rather than insomnia; they often have a febrile stage and a stage of severe pain in various parts of the body and will usually show some degree of optic neuritis on fundus examination, none of which appear in botulism.

From poliomyelitis

Poliomyelitis should usually be easy to identify; the characteristic tenderness and stiffness of the neck, the paresis of groups of muscles rather than a general weakening, the absence of the dryness of the mouth and throat characteristic of botulism and the prodromal febrile symptoms are diagnostic.

From belladonna poisoning

Poisoning with belladonna and other poisonous Solanaceae presents some of the features of botulism and may also arise from a toxic meal. Dryness of the mouth and dilatation of the pupil are, moreover, found in both. But congestion of the face, fever, loss of consciousness, delirium and abnormally rapid pulse, all characteristic of acute belladonna poisoning, are in strong contrast to the symptoms of botulism. Milder grades of poisoning with toxic solanaceous plants in which sufficient alkaloid has been ingested to produce dilatation of the pupils and dryness of the mouth may be distinguished by the absence of paralysis of ocular muscles and by the rapidity of recovery, in contrast to the slowly progressive paresis of botulism.

From mushroom poisoning

Mushroom poisoning, though likewise associated with food, should rarely be mistaken for botulism. The symptoms usually come on with great rapidity and are primarily those of violent gastro-intestinal irritation; the subsequent course depends on the species of poisonous fungus ingested, but perspiration, salivation, severe abdominal pain with hallucinations and delirium are characteristic of the commonest poisonous genus, the *Amanitas*, and are rarely, if ever, present in botulism.

Other types of food poisoning

The contrast between botulism and the common types of food poisoning, e.g. salmonella infections and staphylococcus toxin outbreaks, is obvious—vomiting, violent diarrhoea and severe abdominal pain being almost invariably symptoms in the latter. The normal temperature of botulism also distinguishes it from other forms of bacterial food poisoning, in which some rise of temperature and increased rapidity of pulse are usual.

6.–TREATMENT

Treatment of the botulism patient is: *specific*, by the administration of the botulinus antitoxin; *physical*, by the artificial maintenance of respiration when paralysis of the respiratory muscles sets in; and *pharmacological*, counteracting the toxic effects by drugs having a contrary pharmacological action.

Antitoxin

Specific antitoxin therapy should be employed in every case regardless of the mildness of the initial symptoms, and large quantities of a high-titre serum should be given in all severe cases. No official standard of potency exists but no botulinus antitoxin should be used containing less than 100 units per 1 c.c., the unit being the amount of serum necessary to neutralize 100 minimal lethal doses of the toxin for guinea-pigs. Prompt administration is of prime importance, since it is probable that, although absorption of toxin from the alimentary canal and its fixation by the susceptible tissues is comparatively slow, once it is so fixed, neutralization by circulating antitoxin is difficult or impossible. In England a supply of botulinus antitoxin is maintained under the control of Medical Officers of Health at sixteen provincial centres, and is available also at the Ministry of Health, Whitehall, London, at any hour of the day or night.

Technique

Intravenous administration is always preferable in a severe case, the risk of serum reaction being ignored in view of the desperate nature of the illness. The serum should preferably be well diluted in physiological saline, 10 c.c. being mixed with, say, 100 c.c. of warm saline and slowly infused intravenously by gravity in the course of twenty minutes; or, a continuous-drip feed of glucose-saline (5 per cent pure glucose) intravenous infusion, itself a valuable therapeutic measure, may be arranged and the serum added in small doses from time to time by puncture and injection into the rubber tube leading from the reservoir. But, if those procedures involve delay, direct injection of the undiluted serum into a vein is advisable, due care being taken to inject as slowly as possible.

Dosage

Almost no limit need be put on the amount injected in a severe case; 10 c.c. every hour until paralysis ceases to progress would not be too much. The prophylactic dose for those who have partaken of the toxic food but who are not yet ill should be 10 c.c., and may be introduced intramuscularly.

As regards the 'type' of antitoxin it is generally advisable to use type A or a mixture of A and B, unless the botulinus infection is known to be B or C in which case the appropriate antitoxin would be preferred.

Physical treatment

As soon as signs of dyspnoea appear and before they become pronounced, arrangements should be made for some form of artificial respiration. There are several types of apparatus including the Drinker box, the Bragg-Paul jacket, Eve's 'rocking respirator' and Cowell's Double-Link Action apparatus. The two latter depend on tilting the body so that the weight of the abdominal viscera pushes up the flaccid diaphragm at regular intervals; they involve rather greater disturbance of the patient and are less suitable for the prolonged application which may be necessary in botulism than the two former. A stretcher poised on a trestle and rocked rhythmically through 50° each way may suffice in an emergency. The Drinker box and the Bragg-Paul jacket can be procured from Messrs. Siebe Gorman & Co. Ltd., 187 Westminster Bridge Road, London, S.E.1; both are worked electrically. (See the article on RESUSCITATION.)

Drugs

Morphine

The most valuable drugs are morphine and posterior pituitary extract. Morphine sulphate should be given in doses sufficient to produce almost continuous somnolence; its action is to conserve the waning muscular strength by lessening the number of voluntary movements, each of which is followed by prolonged exhaustion of the muscles employed. Posterior pituitary extract relieves the intestinal atony and its administration is essential if the purgatives, necessary to empty the bowel of possible remains of toxic food, are to be effective. Drugs of the physostigmine group, in spite of their apparent pharmacological suitability, have not in practice been found to influence the symptoms or course of botulinus intoxication either in human cases or in experimental animals, and should be avoided. The same may be said of the drugs which neutralize the action of curare (e.g. congo red), in spite of the close similarity of curare poisoning to botulism.

Pituitary extract

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BRADYCARDIA

See ARRHYTHMIA, p. 27

BRAIN ABSCESS

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Reference may also be made to the following titles:

BRAIN: REGIONAL DIAGNOSIS
BRAIN TUMOUR
CEREBROSPINAL FLUID

1.–AETIOLOGY

187.] The commonest source of cerebral abscess is suppuration in the middle ear, which accounted for 56 per cent in a series of 194 cases *Suppuration* recently collected by Evans from post mortem statistics. In the same series suppuration in the nasal cavity, or its accessory sinuses, was responsible for 7·2 per cent.

Trauma

Trauma is another, but less common, cause of cerebral abscess from direct invasion. Such an abscess may follow a large compound fracture or, perhaps more commonly, a small puncture of the skull, as by a nail or other sharp object.

Blood infections

The most frequent source, after direct invasion from otitis media, is infection from the blood-stream. In this group of cases, amounting to 24 per cent in Evans's series, intrathoracic suppuration (bronchiectasis or empyema) accounted for nearly half the number; the rest arose from various forms of pyaemia. Of these, staphylococcal infection is the most important, both numerically and for the reason that the symptoms which attend invasion of the blood-stream by this organism may be mild and fleeting, and those which betray the cerebral focus of slow development. The connexion, therefore, between the cerebral symptoms and a past history of a boil or carbuncle with some general illness is often missed.

In a small number of cases an abscess of the brain may be discovered without any clinical or post mortem evidence of the source of infection.

2.–CLINICAL PICTURE

The symptoms of cerebral abscess fall into three groups: toxic symptoms; symptoms of increased intracranial pressure; and symptoms resulting from local damage to the brain. All these are usually present in some degree, but any one group of symptoms may preponderate, so that we may for instance see one patient, whose leading symptoms are those of a focal lesion with little evidence of increased intracranial pressure, and another with headache, vomiting and papilloedema, but without any significant localizing signs—the toxic symptoms in both cases being little in evidence. More rarely, are encountered cases in which an obscure pyrexia, associated with headache and severe toxic symptoms, has aroused the suspicion of a general infection, such as enteric fever.

Abscess from direct invasion: stages

When the abscess develops as the result of direct invasion, as from the ear or frontal sinus, the evolution of symptoms, as a rule, comprises three stages. In the first, that of invasion, there may be complaint of headache, and if the patient is under medical observation, a transient rise of temperature may be noted. The symptoms of this stage are often fleeting and of insufficient degree to excite attention. Following this is a stage which may last several weeks or months, during which the abscess is clinically latent. In the third stage, symptoms of local damage and increased intracranial pressure develop.

In some cases, however, the symptoms of the first stage are progressive; the temperature remains high, and severe headache and drowsiness supervene, together with localizing signs. In some of these fulminating cases death ensues within a few days of the onset of symptoms, but in a fair number the process of suppurative encephalitis resolves to form an encapsulated abscess. It is in this group of cases, especially, that the surgeon is advised to hold his hand until subsidence of the acute symptoms warrants the assumption that the abscess has become encapsulated.

Abscess from pyaemia

In the pyaemic cases the cerebral metastasis is usually marked by a rise of temperature, with headache and malaise; a fulminating course is of more common occurrence, especially in cases originating from intrathoracic suppuration, but the initial symptoms may subside and be followed by the long latent interval which, as already mentioned, is characteristic of the abscess resulting from direct invasion.

It has already been implied that an encapsulated or chronic abscess may exist for weeks or months without causing symptoms. Retrospective inquiry will sometimes show that during this period there have been symptoms, such as occasional headache, malaise, anorexia, loss of weight and constipation, though the patient may have been leading a normal existence.

Late symptoms

The transition from the stage which is clinically latent to that in which symptoms of increased intracranial pressure are evident is probably never abrupt, but may be rapid, so that a patient, who has been doing his work without difficulty, may in the course of a few days develop all the symptoms of serious cerebral illness. Headache of increasing severity is the symptom which, as a rule, arouses the first suspicion of intracranial mischief. The association of drowsiness, and perhaps vomiting, is important, but usually it develops later. Papilloedema is an inconstant accompaniment of this stage, valuable as a diagnostic point if present, but often lacking even to the end. The headache, though it may be intermittent, is often severe. In a cerebellar abscess it is frequently referred to the back of the head and neck, though the pain may radiate forward to the temple and brow. When the abscess is above the tentorium the headache is often generalized, but an abscess situated in the lower part of the temporal lobe may give rise to pain which is referred to that part of the head.

Sometimes, as already stated, the symptoms of increased pressure may be of negligible degree, and the patient is brought, not for headache or drowsiness, but for symptoms referable to the local lesion, such as dysphasia or ataxy. This clinical picture is more often encountered in children than in adults.

It is the abscess situated in one of the 'silent' areas of the brain—frontal or right temporal—which is most likely to present no symptoms other than those of increased intracranial pressure—headache, vomiting and papilloedema—and which may, in the absence of any history of infection, be discovered in the course of an exploration for suspected tumour.

In the later stages of a cerebral abscess, the pulse and temperature are, as a rule, normal or sub-normal. The cases with a swinging temperature and toxic symptoms are usually of pyaemic origin, and it may be that the pyaemia, rather than the abscess, is responsible for these symptoms. Occasionally, however, an abscess which has arisen from direct spread of infection may in its later stages present a clinical picture of this kind. Usually in such a case there is an extradural as well as an intracerebral abscess. The development of an intracranial abscess from middle-ear disease, and especially an abscess in the cerebellum, is not infrequently preceded by lateral sinus thrombosis with its attendant symptoms.

Extradural abscess

Extradural abscess is invariably the result of direct spread of infection from the bone, arising from otitis media, frontal sinusitis or local osteomyelitis of the skull. It most commonly occurs in the middle fossa from otitis media. An extradural abscess is rarely of such a size as to cause symptoms of increased intracranial pressure, or even localizing signs from compression of the underlying brain. It is more apt, however, than a cerebral abscess to be a cause of toxic symptoms and, occasionally, of fever. The predominant symptom is neuralgic pain, which, in the case of an abscess in the middle fossa, is referred to the temple, occiput and brow on the affected side. Such pain may be continuous, or may occur in bouts over a period of many months without the appearance of any other signs, though it may from the first be associated with, or later be followed by, an abscess in the underlying brain. The cerebrospinal fluid in a case of extradural abscess is often normal, but it may show changes of the kind seen in cerebral abscess.

Subdural abscess

Subdural abscess also results only from direct invasion from infected bone. It is rare and its symptoms are with difficulty distinguished from those of an abscess in the subjacent brain. Occasionally, however, one of these abscesses originating from otitis media may cause attacks of Jacksonian epilepsy. This is a symptom which, in the absence of generalized meningitis, does not occur with temporal lobe abscess.

3.—PROGNOSIS

Pathological studies leave no doubt that brain abscess can subside spontaneously. Such a course is, however, rare and is apt to be followed after a variable interval by rapid formation of a new abscess in the neighbourhood of the old one. It may be assumed for practical purposes that without operation the outcome is almost invariably fatal.

Causes of death

The most frequent cause of death in brain abscess is diffuse purulent leptomeningitis. The abscess ruptures into the adjacent ventricle or into the subarachnoid spaces. In a considerable number of cases, however, especially in abscess of the cerebellum, death is due to local or general rise of intracranial pressure without any severe spread of infection; the patient becomes unconscious and dies after a few hours, not infrequently from sudden failure of respiration. In other cases the onset of coma may be followed by fatal broncho-pneumonia; this is particularly common when the brain abscess is secondary to bronchiectasis.

Patients with brain abscess may also die from septicaemia or from meningitis, the result of spread of infection—not from the brain abscess itself, but from the primary pyogenic focus.

Mortality

The results of operation are better for cerebral than for cerebellar abscess, but the mortality rate on the whole is to-day high, especially in acute cases. The remarkable success of Clovis Vincent with a new method for treating acute abscesses gives hope for improvement in the results.

4.–DIAGNOSIS

(1)—Blood and Cerebrospinal Fluid

Blood picture

The leucocyte count in cerebral abscess is not very often of value as a guide to diagnosis. It is often normal, and even if raised seldom reaches a figure that provides conclusive evidence of the presence of pus.

Cerebrospinal fluid

Examination of the cerebrospinal fluid almost always provides conclusive information. Lumbar puncture in a case of suspected cerebral abscess is, however, by no means without danger. In all patients with a severe degree of increased intracranial pressure there is some risk of a sudden increase of pressure upon the medulla, and in the presence of an abscess there are the additional dangers of provoking the spread of meningitis, or the rupture of a supra-tentorial abscess into the ventricle. When the diagnosis can be clearly arrived at without its aid, lumbar puncture is, therefore, perhaps best omitted. If it is to be performed, the stage should first be set for operation, the patient being moved into a hospital or nursing home for the purpose. A fine needle should be used and no more fluid removed than is necessary for the examination; 2 c.c. should suffice and, if a manometer is used, its contents should not be wasted.

The pressure of the cerebrospinal fluid may be grossly increased or within normal limits. The most constant abnormality in its constituents is a rise of protein from the normal 0·03 per cent to a figure in the neighbourhood of 0·1 per cent. With this there is also usually an increase of cells to between 10 and 200 per c.mm. Unless there is an associated meningitis, or the abscess is leaking into the ventricular system, the majority of cells—sometimes all—are mononuclear, but a small proportion of polymorphonuclear cells usually affords evidence of a suppurative process. It must, however, be admitted that in rare instances a chronic encapsulated abscess may be present with a normal cerebrospinal fluid.

(2)—Localizing Signs

The localizing signs of cerebral abscess cannot be covered completely in this section. The reader is referred to the article entitled BRAIN: REGIONAL DIAGNOSIS (p. 609). But in view of the preponderance of abscess from middle ear infection, and (to a much less degree) from the nasal sinuses, the signs of abscess in the temporal lobes, cerebellum and frontal lobes will be described briefly.

(*a*) *Right Temporal Lobe*

An abscess in this situation usually gives rise to no localizing signs unless it reaches a large size. The diagnosis commonly rests upon the association of a right-sided otitis media with headache (often referred to right temple and brow), examination of the cerebrospinal fluid, and exclusion of cerebellar signs, rather than upon positive evidence of temporal lobe damage.

Symptoms

Apart from the occasional presence of papilloedema, the earliest neurological sign is usually a slight weakness of the left side of the face, particularly in its lower half, seen when the patient is smiling or showing the teeth. A large abscess may cause more evidence of left hemiparesis, the weakness being first apparent in the hand; and with this the abdominal reflexes on the left are diminished or lost, and the plantar response becomes extensor. An abscess involving the posterior part of the lobe not infrequently presses upon the fibres of the optic radiation causing an homonymous hemianopia usually beginning with loss of the upper quadrants. Rarely an abscess may extend far enough forward to involve the uncinate gyrus and cause epileptic attacks with the characteristic uncinate aura—a momentary unpleasant and indefinable smell or taste, sometimes associated with loss of consciousness and movements of lips or jaw.

(*b*) *Left Temporal Lobe*

Disorders of speech

To the signs already described of a right temporal lobe abscess there are added, in the case of a right-handed person, those which may result from interference with the function of speech. The commonest variety is that known as nominal dysphasia. The patient understands all that is said to him, and can both read and write. In ordinary conversation he may show no abnormality, but, when asked to name in succession a series of a dozen objects, he fails perhaps over one, describing it in terms of its use, or having recourse to a synonym. An abscess situated in the posterior and upper part of the lobe may cause a more general disorder of speech, in which comprehension of the spoken and written word are impaired. It is on account of the dysphasia, which is often a prominent symptom when looked for, that an abscess in the left temporal lobe is more easily recognized than one in the right; but an abscess may be present in the middle part of the left temporal lobe without localizing signs.

(*c*) *Cerebellum*

The importance of pain referred to the suboccipital region has already been mentioned in connexion with cerebellar abscess. This is often associated with bouts of occipito-frontal headache, and vomiting is of rather more frequent occurrence in association with the headache than in the case of a supra-tentorial abscess. Papilloedema also occurs, on the whole, earlier than in the case of a temporal abscess.

Ataxy

The signs of a unilateral cerebellar lesion, as seen with an abscess, are as follows. Nystagmus is important, and nearly always present. It is usually coarser and slower on deviation of the eyeballs to the side of the abscess, though often present also on looking to the other side. In some cases an unwillingness or slowness in deviation of the eyes to the affected side is the precursor of nystagmus, and at rest there may be deviation of the eyes to the opposite side. The upper limb on the affected side is ataxic. This sign is made apparent by asking the patient alternately to touch his own nose and the observer's finger, or to perform other tests needing accurate co-ordination.

In standing or sitting, the head is sometimes tilted, the occiput, as a rule, being inclined to the shoulder of the affected side. In walking the patient may stagger and deviate towards the affected side.

Attacks of vertigo may occur in cases of cerebellar abscess, and are difficult, if not impossible, to distinguish from those caused by labyrinthine disease. In the later stages symptoms of pressure upon the medulla may be conspicuous—slowing of the pulse, periodic slow breathing, attacks of unconsciousness, dysarthria and dysphagia.

(*d*) *Frontal Lobe*

Mental symptoms

Localizing signs in a case of frontal abscess are often absent or inconspicuous. There is perhaps a greater tendency than in the case of an abscess elsewhere for the patient to show evidence of mental dilapidation. Apart from drowsiness there are apathy, inattention, defective memory for recent events and deterioration of the personality. The abscess arising from sinusitis usually lies in the anterior part of the frontal lobe and it is only, therefore, when it attains a large size, or is surrounded by a large area of oedema, that signs of hemiparesis, or motor dysphasia, develop. At this stage attacks of Jacksonian epilepsy sometimes occur. It must be admitted of the frontal abscess, as of that in the right temporal lobe, that the diagnosis usually rests upon the association of a known infection of the neighbouring bone with the general signs of an intracranial abscess.

(3)—Exploratory Puncture

When the diagnosis of abscess appears probable, and there is reasonable evidence of its situation, either from the clinical signs or the presence of a source of invasion, exploratory tapping may be usefully employed for its localization. In a few cases, in which the patient becomes partly or completely comatose before full examination of the nervous system has been made, it is the only way in which the diagnosis can be made.

Technique of exploratory puncture

Through a surgically clean field a small burr hole is made in the skull, and the brain is explored by a hollow, blunt needle. The exploration can be carried out without appreciable damage to the brain, and in such a way as to afford reasonable certainty that an abscess is not overlooked, for an abscess in one cerebral hemisphere invariably produces great collapse of the corresponding lateral ventricle, while the capacity of the opposite ventricle remains normal or is even slightly increased.

The usefulness of this procedure can be demonstrated in various types of cases. Thus, following mastoiditis, an abscess may be suspected in one temporal lobe, but the diagnosis may not be certain owing to the possibility that the symptoms may actually be produced by focal leptomeningitis or some other lesion. An incision can be made over the temporal lobe through a sterile field, and the brain can be gently explored for abscess by passing a hollow needle. If no abscess is present the temporal horn of the lateral ventricle should be encountered at a depth of 4 to 6 cm. and should yield over 5 c.c. of cerebrospinal fluid. Such a finding virtually excludes the presence of abscess, not only in the temporal lobe but in any other part of that cerebral hemisphere. If there is a cerebellar abscess both lateral ventricles are dilated, and each yields more than 15 c.c. of fluid when tapped.

This method of exploratory tapping is probably not often enough used. In the past most explorations for brain abscess have been made through infected wounds, such as mastoid wounds, owing to the belief that it was necessary to follow the track of the abscess from the diseased bone into the brain. But tracks may not exist, or may be so small that they are only visible under the microscope.

(4)—Ventriculography

In certain cases it may be necessary to obtain more precise knowledge of the situation of the abscess than that given either by clinical investigation or by exploratory puncture, and then the ventricles must be filled with air and radiograms taken. This method is dangerous unless immediately followed by operation. Recent experiences, however, have shown that with this precaution it can be used even in acute cases of abscess with satisfactory results (Clovis Vincent).

(5)—Differential Diagnosis

Cerebral symptoms following mastoid operation

Cerebral symptoms occurring in association with otitis media may be due to causes other than abscess. It is not very uncommon, for instance, for a patient, especially a child, after a mastoid operation, to exhibit headache and a slight rise of temperature, perhaps for a week or two, without any subsequent developments. In some cases the cause of these symptoms is obscure, in others they are due to a mild and transient meningitis. Whenever a phase of this kind gives rise to the suspicion of intracranial infection, it is advisable to examine the cerebrospinal fluid. If it shows abnormality, the patient should be kept under observation for several months with the possibility of an abscess in mind, the examination of the cerebrospinal fluid being repeated and a normal report obtained before he is discharged.

Diagnosis from acute purulent meningitis

The symptoms of an acute, purulent meningitis may resemble those of a cerebral abscess, and the two conditions are often present together. Examination of the cerebrospinal fluid will provide the evidence of meningitis. A co-existing abscess may reveal itself by the presence of characteristic localizing signs, but in the presence of meningitis an abscess is sometimes only revealed by exploratory tapping.

From otitic hydrocephalus

There is another uncommon, but important, cerebral complication of otitis media, sometimes known as otitic hydrocephalus, whose symptoms may closely resemble those of an abscess. The history of such a case generally, but not always, includes the story of a lateral sinus thrombosis. The patient, usually a child, has attacks of headache and vomiting with papilloedema, but localizing signs are absent, and between the attacks of headache the patient appears alert and well. The cerebrospinal fluid is under grossly increased pressure, but its constituents are normal. These features taken together almost always suffice to make the distinction from abscess clear, though no single one of them is infallible. The differential diagnosis is of great importance since the patients with hydrocephalus recover if treated by lumbar puncture, without operation.

From labyrinthitis

Labyrinthitis occurring in otitis media is often difficult to distinguish from a cerebellar abscess. Vertigo, nystagmus, headache and vomiting are common to both. The vertigo of labyrinthitis is, however, as a rule more severe, lasts longer than that met with in cerebellar abscess, and is often associated with a sudden onset of deafness and tinnitus. Moreover, in labyrinthitis the inco-ordination of voluntary movement, as elicited by the finger-nose test, is lacking, whereas it is usually present if the lesion is in the cerebellum. Labyrinthitis and cerebellar abscess may, however, co-exist.

From tuberculous meningitis

Tuberculous meningitis, especially if there are focal symptoms, may have to be distinguished from cerebral abscess, but a full examination of the cerebrospinal fluid will almost always make the distinction clear.

From general pyaemia

In a small group of cases, already mentioned, the differential diagnosis from a general infection, such as enteric fever, may arise. These are usually pyaemic abscesses of which the source is often obscure. Thorough neurological examination, together with examination of the cerebrospinal fluid, will usually suffice for a correct diagnosis.

From intracranial tumour

The differential diagnosis from intracranial tumour is most likely to arise in the case of a chronic abscess causing symptoms some time after a mild (usually staphylococcal) pyaemia, or a similar abscess developing long after an acute and transient infection of the middle ear or nasal sinuses. Such cases are rare; they are sometimes disclosed only at operation. The presence of an occasional polymorphonuclear leucocyte in the cerebrospinal fluid may afford the clue.

5.–TREATMENT

The method of treating brain abscess varies according to the age of the abscess and the firmness of its capsule. In the acute stage, which comprises the first three to four weeks from the time of infection, the abscess is not firmly walled off from the surrounding oedematous brain and there is considerable risk that operative intervention will favour rather than prevent the onset of fatal meningitis.

The policy of delaying operation after diagnosis and localization must be based on a fairly accurate conception of the age of the abscess and the state of the infection. The age of the abscess can usually be accurately gauged from careful attention to the history of illness, and the state of infection is indicated by the cerebrospinal fluid. In acute abscess without meningitis it is wise to delay operation whenever possible. In acute abscess with a large increase of cells in the fluid (up to 1,000 per c.mm.) it is also generally best to delay, watching the patient and sampling the spinal fluid from time to time. In cases of acute abscess with living organisms in the cerebrospinal fluid, the state of the patient may be so desperate that immediate operation is justified. With chronic abscess there is no reason for delaying operation.

Operation of Clovis Vincent

If the surgeon must intervene in the acute stage on account of the severity of coma or the risk of broncho-pneumonia, the method of Clovis Vincent is probably the best. The abscess is localized precisely by ventriculography and then, without any preliminary needling to prove the presence of pus, a large osteoplastic flap is reflected over the site of the lesion. The abscess is then aspirated and when it has been emptied as completely as possible, the bone flap is replaced without the dura being opened. At a later stage, after an interval of weeks, during which further aspiration may be carried out through one of the burr holes if necessary, the flap is raised again and the abscess, now firmly encapsulated, is dissected out intact. With this method Vincent and his assistants have had six recoveries in seven consecutive acute abscesses.

Another method, advocated by King for the treatment of acute abscesses, is a wide exposure of the abscess by piecemeal removal of bone, and excision of the overlying brain. In the days after operation a fungus forms and is controlled by repeated lumbar punctures.

Drainage of chronic abscess

Chronic recently encapsulated abscesses may be treated by drainage through a small hole in the bone and dura nearest to their most superficial part. Various types of drain have been recommended, but free exposure and drainage rather than the manner of drainage is the important point. If the abscess is subcortical a useful additional procedure is to remove sufficient of the overlying brain to get a good exposure of the capsule and then to marsupialize the abscess capsule by stitching it to the pericranium at the edges of the bone defect.

These operations are all performed through a hole in the skull no larger than 4 to 5 cm. in diameter, and sometimes the exposure of the abscess may be inadequate. Whenever there is difficulty of exposure in the early stages of operation, it is advisable to convert the operation into a much wider osteoplastic exploration, after which the abscess can be treated under direct vision. The risk of spreading meningitis from this cause is much less than might be expected and, in fact, the results of treatment of encapsulated abscess through an osteoplastic flap are usually satisfactory.

Excision

With an abscess of long standing, treatment through an osteoplastic flap is the method of choice. In some chronic abscesses the capsule is so thick that the abscess must be removed intact like a tumour; in others the abscess is loculated to such an extent that thorough drainage is impossible and excision is the only treatment; in yet others there are two or three separate though contiguous chronic abscesses.

Repeated aspiration of an abscess through a small burr hole, without recourse to permanent drainage, has been advocated by some, but it is not to be recommended in most cases. For the rare abscess that contains many living organisms this method, or passing an indwelling rubber catheter into the abscess through a small opening in the skull, is useful as a preliminary to a more extensive operation at a later date.

After-treatment

After-treatment requires great care and should be carried out by the surgeon who drained the abscess. Not the least important part of it is careful and repeated neurological examination to watch the improvement, if any, in functions which were disturbed before the abscess was treated. If the abscess is draining properly, such improvement is to be expected. When an abscess has been satisfactorily treated the cellular and protein content of the lumbar cerebrospinal fluid become normal again; persistent increase of the cells or excess of protein means that all is not yet well.

It is necessary to add that so far little success has attended the surgical treatment of brain abscesses secondary to bronchiectasis or chronic empyema. These abscesses are often multiple. Furthermore, they induce a state of drowsiness that is fatal to patients with bronchiectasis, for when such patients become so drowsy that they can no longer cough up the pus in their lungs acute broncho-pneumonia almost invariably follows.

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BRAIN: REGIONAL DIAGNOSIS

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Reference may also be made to the following titles:

APOPLEXY
BRAIN ABSCESS
BRAIN TUMOUR
BRAIN: VASCULAR DISORDERS
CEREBELLAR DISEASES
CRANIAL NERVE AFFECTIONS

188.] With the sole exception of the head of the optic nerve, which may be viewed in the fundus oculi, the brain enclosed within the bony framework of the skull is wholly inaccessible to observation.

The methods of palpation, percussion and auscultation which help us to localize disease within the viscera and to determine its probable nature are of no avail in the study of diseases or injuries of the brain, and we are therefore dependent upon observations of disorders of function in tissues innervated by the brain when making a localizing or pathological diagnosis of disease or injury of the brain. Occasionally, it is true, a radiogram may provide direct information, but the first and sometimes the only line of approach is clinical. We have to consider, therefore, the various ways in which disease may disorder the functions of the brain, and also to review briefly what is known of the localization of function within this organ, that is to say, to state as far as they are known the situations within the brain in which the various functions and structures of the body are represented.

With the information derived from these two sources we may hope to determine both the seat and the nature of the disease.

1.–DISORDERS OF FUNCTION PRODUCED BY DISEASE OR INJURY

Direct symptoms

The effect of local disease of the brain may be to destroy the normal functions of the region affected ('paralytic' symptoms) or to exalt them ('irritative' symptoms). Not uncommonly irritative symptoms are followed by those of paralysis or loss of function, e.g. a Jacksonian convulsion followed by temporary paralysis of the convulsed part. In both instances we speak of these symptoms as directly produced.

Indirect symptoms

'Shock' symptoms

The brain, despite a high degree of localization of function within it, normally acts as a whole and tends to respond as a whole to injury of one of its parts. The functions of parts not directly affected by the disease may be disturbed by a local lesion elsewhere in the brain; such symptoms are said to be indirectly produced. Thus, a cerebral haemorrhage produces hemiplegia directly by destroying the motor fibres in the internal capsule; such an event is commonly accompanied by a period of coma (the apoplectic stroke) not due to destruction of motor fibres, but to a temporary disorganization of all those parts of the cerebral hemispheres which normally function consciously. This temporary cessation of the higher cerebral functions is spoken of as a 'shock' symptom.

'Release' symptoms

There is a fourth and very important group of symptoms, the group of 'release' symptoms. The hemiplegia which results from a haemorrhage into the substance of the cerebral hemisphere is at first flaccid; the paralysed limbs, however, as they regain some function gradually become hypertonic or 'spastic', the tendon-reflexes become exaggerated, and the plantar response of the affected leg is of the Babinski or 'extensor' type. The muscular hypertonus and the increase of the tendon reflexes indicate an excess of functional activity, and we conclude that the nervous mechanisms responsible for their production and maintenance have been released from some process of control or inhibition normally exercised over them by the higher-level mechanism (the pyramidal system of fibres in this case) now destroyed by the haemorrhage. Similarly, there are grounds for believing that the Babinski plantar response results from the release from inhibition of a spinal reflex reaction. Such symptoms, then, are rightly spoken of as release symptoms and, like the directly produced paralysis of function, may persist undiminished for the rest of the patient's life. On the other hand, shock and irritative symptoms are usually transient.

There are therefore four types of disorders of function, paralysis and exaltation of function (directly produced), and shock and release symptoms (indirectly produced).

In some chronic maladies of the brain release symptoms may dominate the clinical picture throughout. Thus the tremor and muscular rigidity which are so striking in paralysis agitans are both release symptoms, and the same is true of the striking disorders of co-ordination seen in some cases of cerebellar disease.

Factors determining clinical picture

Three other factors play an important part in determining the character and severity of the disorders which will be produced by disease of the brain. The more rapidly a lesion develops the greater will be the disturbance of function; thus an injury to the cerebellum may evoke the wildest ataxy of movement, although a slowly growing tumour in this region may produce very little recognizable disorder of cerebellar function. Age is also a factor; thus a tumour of the brain in an elderly person tends to cause a less striking disorder of function than a tumour in a child. Furthermore, the range of likely pathological processes is wider in the elderly than in children, and for this reason the determination of the nature of the lesion may be more difficult in an elderly patient. The factor which has the greatest effect in determining the clinical picture produced by disease of the brain is the situation of the lesion. The various localizing symptom-complexes whose importance in diagnosis is best established are given below. In each case mention is made of the nature of the lesion most likely to be found, for, as has been stated earlier, this and the time factor involved in it do influence the observable disorders of function.

2.–SYMPTOM-COMPLEXES ASSOCIATED WITH:

(1)—Lesions of the Frontal Lobe (Pre-Rolandic Area)

We deal here with that part of the frontal lobe which lies anterior to the so-called 'motor cortex', or Rolandic region. Frontal lobe lesions are relatively uncommon in children, but in adults new growth is extremely common in this region. Less common are abscess and thrombosis within the area supplied by the anterior cerebral artery. As with tumours elsewhere in the brain, there may be no unequivocal localizing signs, but when any are present they consist of changes in the mental and emotional state, and, less constantly, certain disorders of movement including motor apraxia (in left-sided lesions) and what is known as 'forced grasping'. If the lesion extends backwards it may

Symptoms

produce some hemiparesis and, again in left-sided lesions, some motor aphasia.

Mental symptoms

Mental impairment occurs with tumours in other situations in the brain, but in frontal lesions often ushers in the clinical course. It consists in defects in memory and in the association of ideas. The patient becomes silent and apathetic, tends to remain motionless and to answer questions monosyllabically and after some delay. His profound indifference to circumstances sometimes shows itself by a neglect of the calls of nature so that the patient passes urine and faeces wherever he may chance to be and is unperturbed by these events. This altered mental state is most marked when the corpus callosum is invaded by the lesion, and the patient may remain motionless and silent in bed for hours at a time, paying no obvious attention to what goes on around him. He will eat if he is fed, but does not ask for food or drink.

Much less common than the mental reduction briefly described above is an abnormal facetiousness in certain cases of frontal lobe lesion (tumour or abscess, or traumatic lesion).

Forced grasping

Forced grasping consists of a tendency for the affected hand to take hold of any object which lies near it or is presented to it. The patient can relax this grasp at will, but if any attempt is made to take from the hand some object clasped in it, the grasp tightens and becomes very powerful. In these circumstances the patient cannot voluntarily open his fingers. This inability to relax may persist even when consciousness is almost lost, but the spontaneous grasping movements occur only when consciousness is normal.

Motor apraxia

Motor apraxia is seen in the left hand in left-sided lesions and consists of an inability to perform certain purposive movements at will, even though co-ordination and motor power are normal. The patient may not know how to handle familiar objects and may use them incorrectly; thus he may use a pencil as though it were a cigarette. Similarly, he cannot make purposive movements at request although he may be seen to do so spontaneously.

Aphasia and agraphia

Motor aphasia, or an inability to express thought in speech, is a form of motor apraxia, as is also agraphia (inability to write), and is seen in left-sided lesions when these encroach upon the region immediately anterior to the 'motor' cortex.

Anosmia and ocular symptoms

In lesions (tumours) lying on the under surface of the frontal pole there may be unilateral anosmia and loss of vision from primary optic atrophy on the side of the lesion, with papilloedema on the opposite side.

Spastic paresis

Similar signs and symptoms accompany thrombosis within the region supplied by the anterior cerebral artery, but here there is also some spastic paresis of the leg, with the usual changes in the reflexes (increased tendon-jerks, clonus and extensor plantar response).

(2)—Lesions of the Rolandic Region

Immediately anterior to the fissure of Rolando lies the motor cortex, in which movements are represented. Hemiplegia, in its various degrees of severity, is the characteristic expression of a destructive lesion in this situation, or if the lesion be small and circumscribed paresis of one limb (monoplegia) may be seen. With an acute lesion the tendon-jerks are not increased at first, but become so in a week or two. Simultaneously muscular hypertonus, increased tendon-reflexes and clonus appear. When the leg is involved, there is an extensor plantar response. In a slowly progressive lesion, hypertonus and increased tendon-reflexes may be present from the outset. *Symptoms*

Paralysis The loss of movements is maximal in the case of fingers and hand, and spreads thence as paralysis becomes more severe to the movements of the proximal part of the limb. Similarly movements of the distal segments of the lower limb are the more severely affected, and of these dorsi-flexion of the toes and foot are most profoundly impaired. In progressive lesions these are the first to be weakened.

Jacksonian fits The characteristic signs of a stimulating (or irritative) lesion are focal or Jacksonian fits. These begin either in the thumb and index finger, the angle of the mouth or (less commonly) in the hallux. They tend to spread up the limb from the point of onset and the convulsive movements are clonic from the outset. A transient paralysis or paresis of movement may ensue in the convulsed part.

(3)—Lesions of the Temporo-Sphenoidal Lobe

Symptoms Here also tumour is the most common lesion, but otitic abscess is usually situated in this lobe. Localizing signs may be scanty and late in appearance, but when present consist of (1) very slight hemiparesis of the crossed side, most marked in the lower face (and appearing here first from the upward pressure of an expanding lesion); (2) crossed homonymous hemianopia, from involvement of the optic radiations which traverse this lobe on their way back to the occipital pole (see Fig. 102): (3) Jacksonian fits—these consist of transient sensations of smell (more rarely of taste) with a transient blunting of consciousness (the so-called 'dreamy state' of Jackson); occasionally visual hallucinations of an elaborate and formed character may be present with these attacks; (4) in left-sided lesions there may be the so-called 'sensory' or 'receptive' aphasia; the patient hears what is said, but the sounds of words have lost their symbolic character for him and he fails to understand them. Consequently when he speaks he misuses words and may not be able to construct sentences. Whereas in motor aphasia the patient has lost words, in this instance he has words, but wrong words. His speech may thus be a jargon. This defect may be an important diagnostic sign in left-sided temporo-sphenoidal abscess.

(4)—Lesions of the Occipital Lobe

These are relatively uncommon, and are of the nature of new growth (usually) or of thrombosis of the posterior occipital artery. The localizing signs are crossed homonymous hemianopia with sparing of the macula, and occasionally Jacksonian fits which consist of crude

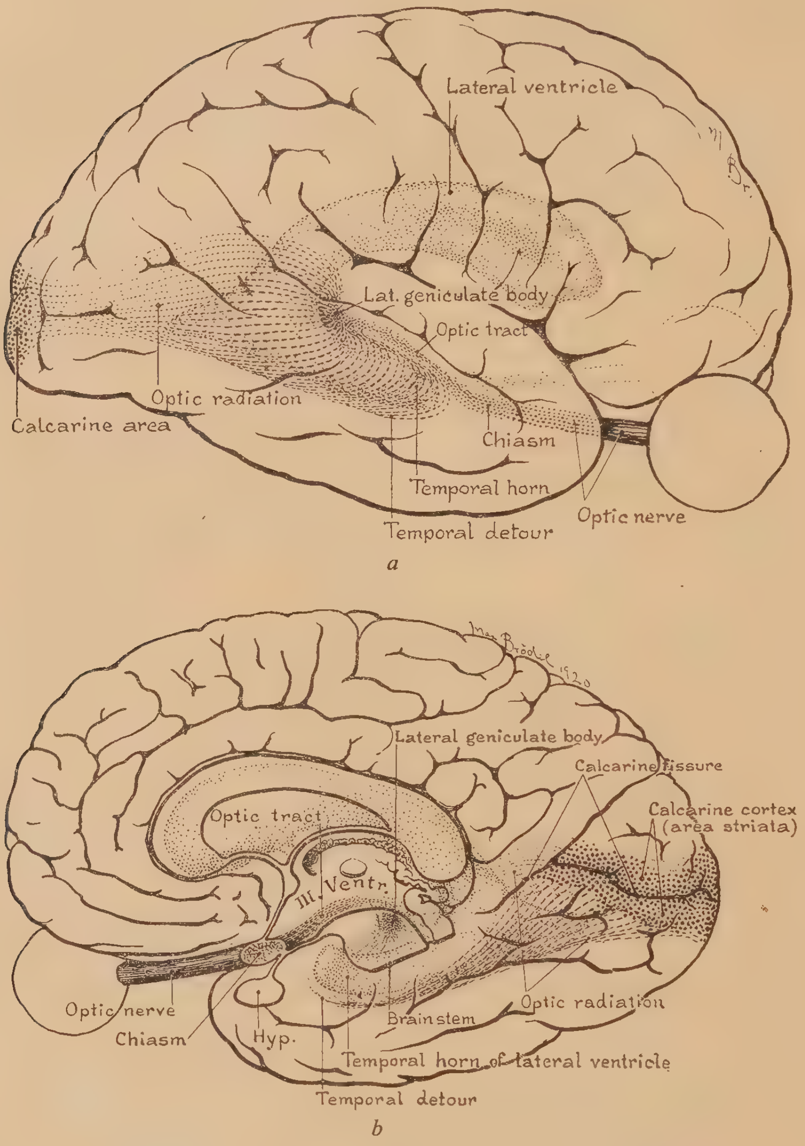

FIG. 102.—These figures indicate on (*a*) the lateral and (*b*) the mesial aspects of the right cerebral hemisphere, the geniculo-calcarine pathway (optic radiations), particularly in its relations with the temporo-sphenoidal lobe and the descending horn of the lateral ventricle. The most anterior part of the radiation which surrounds the tip of the descending horn of the ventricle represents the lower homonymous quadrants of the left visual fields. Hence the earliest defect in the visual field is commonly an upper quadrantic hemianopia. (Cushing.)

(From *Transactions of the American Neurological Society*, 1921.)

sensations of light. In circumscribed lesions the hemianopia may involve only one quadrant of the crossed half-field.

(5)—Lesions of the Parietal Lobe

Sensory disturbances

The sensory cortex is situated mainly in this region, posterior to the fissure of Rolando. The characteristic sensory disturbances of a purely cortical lesion are failure to discriminate between different intensities of cutaneous stimulation, impairment of acuity of tactile sensibility, defects in the localization of tactile stimuli, defects in discrimination of two simultaneous tactile stimuli, and defects in appreciation of the size, shape and consistency of objects held in the hand.

Painful and thermal sensations are normally appreciated. Occasionally 'word blindness' may be present in left-sided lesions. The patient can see written words, but fails to understand their meaning. In the case of tumour, the functions of the motor cortex may be interfered with and some hemiparesis may ensue.

As in the case of all cerebral lesions, the symptoms are crossed.

(6)—Lesions of the Internal Capsule

Hemiplegia is the characteristic result of a destructive lesion, and when the posterior limb of the capsule is involved there is hemi-anaesthesia on the opposite side, and crossed homonymous hemianopia.

(7)—Lesions of the Optic Thalamus

Thalamic syndrome

A characteristic group of sensory symptoms may be seen in lesions (commonly thrombosis) involving the lateral part of this nucleus. There is a crossed hemi-anaesthesia, in which the postural aspects of sensibility (sense of position, appreciation of position, appreciation of size and shape of objects) are most severely affected. Pain and temperature sense are also impaired. There is also a peculiarly unpleasant overreaction to painful stimuli, so that the sensations they evoke (although the threshold of stimulation may be raised) are very distressing and lead to reflex withdrawal of the stimulated part. There is also spontaneous pain on the affected half of the body. Hemiparesis is usually slight and transient, but later involuntary movements and ataxy of movement may develop. This group of symptoms is known as the thalamic syndrome.

(8)—Lesions of the Corpus Striatum and Corpus Subthalamicum

Paralysis agitans

The clinical picture of paralysis agitans (tremor, muscular rigidity, slowness and restricted range of movement) is probably the most common expression of lesions of these masses of grey matter. Lesions localized to the substantia nigra are believed to produce unilateral chorea ('apoplectic chorea'). When lesions of these structures are unilateral, the symptoms occur on the opposite half of the body.

(9)—Lesions of the Optic Chiasma and Pituitary Gland

The lesion in this case is commonly an adenoma of the anterior lobe of the pituitary gland or a tumour of its stalk (hypophysial duct tumour). The symptoms which may ensue are of three kinds, chiasmal symptoms, endocrine symptoms and symptoms of raised intracranial tension. The last-named group may be absent.

Chiasmal symptoms

The optic chiasma lies above the anterior part of the diaphragma sellae, and when compressed by a tumour the decussating fibres of the optic nerves are interfered with and a bitemporal hemianopia ensues. This may not be symmetrical; one temporal field may be wholly lost while in the opposite eye only one quadrant of this field may be lost. Ultimately, if the pressure be not relieved total blindness from primary optic atrophy may develop.

Symptoms of pituitary disease

With the common chromophobe adenoma, the symptoms of hypopituitarism ensue. These are (in children) failure of development of the gonads and of the secondary sexual characteristics. In girls the menstrual function is not established. Other symptoms are obesity, somnolence and polyuria, though these three are not invariably present. In adults the sexual organs undergo regression, and amenorrhoea in females and impotence in males ensue. In the less common chromophile adenoma acromegaly develops (the so-called hyperpituitarism).

Pressure symptoms

When pituitary stalk tumours occur in children, in addition to the chiasmal syndrome and signs of hypopituitarism, papilloedema, headache and vomiting may appear owing to raised intracranial tension. In pituitary adenoma and in the stalk tumours of adults these symptoms are not found.

(10)—Lesions of the Cerebellum

Types of lesions

Here again the lesion most frequently encountered is a tumour, usually a form of glioma. Otitic abscess may also occur in this region. Their symptomatology is coloured by the fact that both are progressive and not acute lesions. Acute vascular lesions are uncommon, though thrombosis of the posterior inferior cerebellar artery gives rise to suddenly appearing but transient cerebellar symptoms.

Symptoms

The essential element in a cerebellar lesion is inco-ordination of voluntary movement. There is no true paralysis, no qualitative change in the reflexes and no sensory impairment. The symptoms occur on the same side as the lesion when this is unilateral.

Cerebellar ataxy

The components in cerebellar ataxy as revealed during clinical examination are largely determined in form by the nature of the tests used to reveal them. There is an inability to keep the extended arms steady, or to make a smooth movement. The limb shows a coarse tremor known as intention tremor. In ocular movements this defect is seen as nystagmus, which in unilateral lesions is coarse when looking to the side of the lesion, and fine and rapid when looking away from it. The movements of the articulatory muscles are similarly affected with the production of a slow and laboured articulation, the so-called 'scanning' or 'staccato' speech. In walking, the disorder shows itself as a tendency to sway, to walk with a wide base, and to fall to the side of the lesion when

Asynergia

this is unilateral. All these defects are sometimes spoken of as asynergia. There is also an inability to perform the rapidly alternating movements of pronation-supination of the forearm, the so-called adiadochokinesis. Another valuable diagnostic sign may be obtained if the extended arms be suddenly depressed by the examiner, who gives them a sharp push downwards. In the normal person the arms are brought quickly to rest, but in cerebellar ataxy they swing pendulum-like for a second or two before coming to rest. This sign is especially striking in unilateral cerebellar lesions, such as abscess.

Symptoms in children

It must, however, be emphasized that in the cerebellar tumours of childhood not all these symptoms may be present. They are masked, or anticipated, by the development of acute internal hydrocephalus, so that the child presents the signs and symptoms of raised intracranial tension (headache, vomiting, papilloedema), bilateral external rectus palsy and no more than some unsteadiness of gait with a tendency to fall backwards.

Perhaps the most striking pictures of cerebellar ataxy are produced by disseminated sclerosis, and by some types of cerebellar degeneration, or (unilaterally) by the cerebellar or extra-cerebellar tumours of adult life.

(11)—Lesions of the Brain-Stem (Mid-Brain, Pons, Medulla)

In its dorsal or tegmental part the brain-stem contains certain reflex centres as well as cranial nerve nuclei, and traversing it are the long projection pathways, afferent and efferent. Most of these pathways are crossed, and therefore the characteristic of a brain-stem lesion is what is known as an 'alternating paralysis', i.e. one with cranial nerve palsies on the same side as the lesion (when this is unilateral) and hemiparesis or hemi-anaesthesia on the other side of the body. The cranial nerves involved are the third, sixth, seventh and twelfth, and the level of the lesion is indicated by the particular cranial nerves affected. Thus, a third nerve palsy indicates a mid-brain lesion, and sixth and seventh nerve palsies indicate a pontine lesion. Tegmental lesions of the mid-brain produce defects in vertical (upward) movement of the eyes with dilatation and immobility of the pupils.

Medullary lesion

One of the most striking pictures of a unilateral brain-stem (medullary) lesion is produced by thrombosis of the posterior inferior cerebellar artery which supplies the lateral portion of the medulla at its upper part. At the moment of onset there is intense vertigo and vomiting. There may be dysphagia, and pain or paraesthesiae with sensory loss over the face on the side of the lesion (involvement of fifth nerve nucleus). There is paresis of the soft palate, pharyngeal muscles and vocal cords (from involvement of the nucleus ambiguus), signs of a sympathetic lesion (enophthalmos, miosis and drooping of the upper lid), and a crossed dissociated anaesthesia (pain and temperature) on the side of the body opposite to the lesion, from involvement of the spino-thalamic pathway. The cerebellar symptoms (vertigo, ataxy) are transient and are due to blockage in the branches of the artery which pass on to the surface of the cerebellum and to the dentate nucleus.

Other brain-stem syndromes are described in the article on cranial nerve diseases.

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BRAIN TUMOUR

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Reference may also be made to the following titles:

ACROMEGALY
ADIPOSITY
BRAIN ABSCESS
BRAIN: REGIONAL DIAGNOSIS
CEREBROSPINAL FLUID
HYDROCEPHALUS
PITUITARY GLAND DISEASES

1.–INTRODUCTION

189.] The scope of this article will be restricted to the new growths which constitute 95 per cent of the space-occupying lesions within the skull. Other conditions which may play the part of intracranial tumour are chronic abscess, aneurysm, tuberculoma, gumma, chronic subdural haematoma and hydatid cyst; these are considered in the appropriate articles.

The symptoms of intracranial tumour are commonly divided into two groups, those which are due to the local effects of the tumour and those which are the result of increased intracranial pressure. The disturbance of neural function which represents the local effect of the tumour, is often due more to pressure or impairment of blood supply (by venous congestion with oedema, or more rarely by arterial obstruction) than to destruction of the nerve cells or fibres. This is true even of invasive tumours, and largely accounts for the occurrence of fluctuation and remission of symptoms. Increased intracranial pressure is sooner or later an inevitable result of a new growth within the closed box of the cranium, but its time of appearance and its degree depend a good deal upon the situation of the tumour as well as its size and nature. Any tumour which from its situation causes symmetrical hydrocephalus will result in an increase of intracranial pressure out of all proportion to its size. For instance a colloid cyst of the third ventricle 1·5 cm. in diameter is capable of distending each lateral ventricle from a capacity of 15 c.c. to 90 c.c., and a small tumour of the cerebellar vermis can raise the pressure of the ventricular fluid, measured in the horizontal posture, from 150 mm. to 1,000 mm. of fluid. In the case of a tumour which invades one of the cerebral hemispheres, and to a lesser degree in one which compresses the hemisphere, oedema of the brain surrounding the tumour is an important factor in the increase of pressure. In the later stages of nearly all cerebral tumours, however, hydrocephalus in some degree plays a part in the causation of symptoms, as the result of distortion and displacement of the intracranial contents, with consequent obstruction of the channels, within and without the brain, through which the cerebrospinal fluid normally flows from its source to its channels of absorption.

2.–PATHOLOGICAL CLASSIFICATION

It is becoming more and more the aim of the neurologist and surgeon to make a pre-operative diagnosis not merely of intracranial tumour but of the kind of tumour present. Broadly speaking intracranial tumours may be divided into those which are benign and those which are malignant—this distinction being made not merely upon the histological criteria but upon the life history of the growth. The arrangement which follows is designed for practical purposes rather than to fulfil the requirements of a precise pathological classification.

(1)—Non-Malignant Tumours

(*a*) *Meningioma* (*Endothelioma*)

Site

This tumour arises from the meninges and usually therefore lies on the surface of the brain, although occasionally it presents at operation as from its depths, as for instance when it grows from the falx cerebri. It is an encapsuled tumour which is embedded in the brain without invading it. It may, however, invade the overlying bone and cause a prominence upon the skull. Its commonest sites are along the great venous sinuses (see Fig. 103), over the Sylvian fissures, and at the base of the skull either above or in front of the sella turcica (suprasellar and olfactory groove meningiomas) or on the lesser wing of the sphenoid.

Character

These tumours are usually composed of fibroblastic spindle cells, and fibrils of collagen, reticulum or fibroglia, and sometimes may be calcified or even contain bone. They are as a rule of slow growth and do not recur when completely removed.

Incidence

Their frequency in a series of over 500 tumours encountered by one of us (H. C.) was 13·9 per cent. They are rarely seen before adult life, and about 80 per cent occur between the ages of 30 and 60. The case mortality reported by Cushing in his most recent series of operations for the removal of these tumours, was in 69 patients 11·6 per cent.

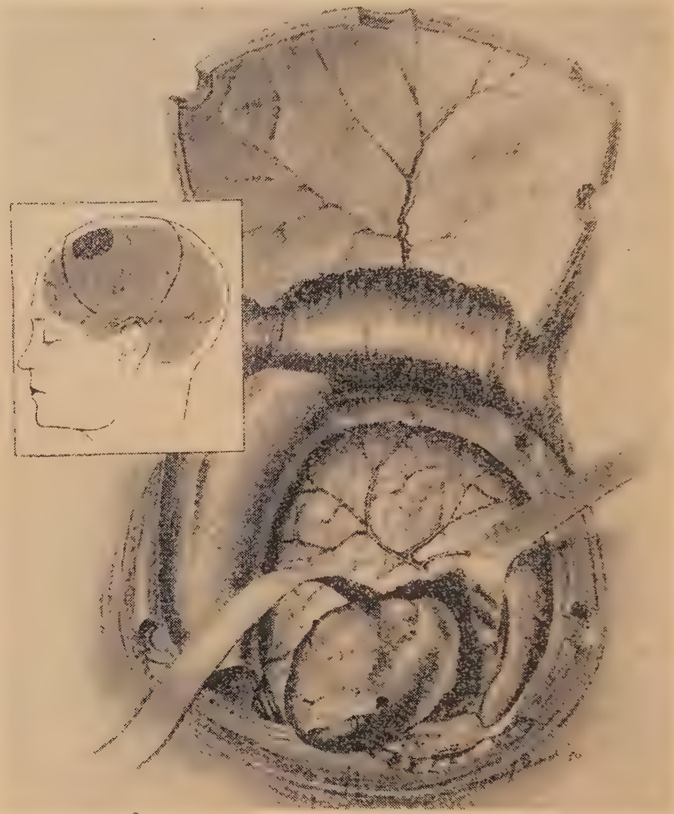


FIG. 103.—Showing removal of parasagittal left frontal meningioma

(b) *Acoustic Tumours*

Character These arise from the sheath of the eighth nerve, usually near its entry into the internal auditory meatus. They are encapsuled tumours of slow growth, and are composed of intersecting bundles of long connective-tissue fibres and cells, with a tendency to lipoid degeneration and, occasionally, cyst formation. As the tumour enlarges it indents, without invading, the lateral aspect of the pons, medulla and adjacent cerebellum, and stretches and flattens the nerves in the cerebello-pontine angle. Occasionally these tumours are bilateral and are then usually associated with a generalized neurofibromatosis (von Recklinghausen's disease) and sometimes also with multiple meningiomas and even gliomatous tumours of the cord. In this association the acoustic tumour may be hereditary. *Incidence* The frequency of these tumours in the series already referred to was 5·4 per cent. They are essentially tumours of adult life and their incidence is spread fairly evenly over the various decades.

Hitherto there has been a high mortality from complete removal of the tumour with its capsule. For intracapsular removal the case mortality in Cushing's most recent series was in 50 cases 4 per cent.

(*c*) *Pituitary Adenomas*

These may be composed of acidophil, basophil, or chromophobe cells. The basophil adenoma is usually of microscopic dimensions and is, therefore, of little or no importance as a space-occupying lesion. It has been associated with a clinical picture of endocrine disturbance—e.g. obesity, hypertrichosis, plethora, arterial hypertension, and glycosuria (see Vol. I, p. 216). The acidophil and chromophobe tumours grow to a considerable size, the latter being three or four times more common than the former. In their enlargement they cause expansion of the sella turcica, and eventually extend into the interpeduncular space, or the frontal or temporal lobes. With rare exceptions they are encapsuled tumours of very slow growth. Their frequency is 10·5 per cent. They are tumours of adult life, 94 per cent being encountered between the ages of 20 and 60. The case mortality (for partial removal) in Cushing's series was 6·8 per cent.

Incidence

(*d*) *Hypophysial Duct Tumours*

These are epithelial tumours derived from remnants of the pouch of Rathke, situated above or within the sella turcica or in the floor of the third ventricle. They are benign encapsuled tumours, usually of slow growth although subject to rapid expansion as the result of cyst formation. They are commonly cystic, but wholly solid tumours may be encountered. The cells of the tumour may take any of the forms seen in the normal stratified squamous epithelium. The cystic fluid is usually rich in cholesterol crystals. Calcification and even bone formation are common. Their frequency is about 4 per cent. These tumours are commonest in early life, but although they arise from developmental cell rests, they may begin to show evidence of active growth at any age, even in the latter half of life.

Incidence

Except when they are small or cystic, total removal is very difficult and carries a high operative risk. Cushing's statistics show that for complete and partial removal the case mortality is about 21 per cent and has not been appreciably reduced in his most recent series.

(*e*) *Blood-Vessel Tumours*

In this group are included angiomatous malformations and the haemangioblastomas. The former consist of a congeries of blood-vessels, which may be either entirely venous (venous angioma), or arteriovenous. Both are congenital, but an important difference between the two is that the arteriovenous angioma tends to increase in size as the result of the abnormally free communication between the arterial and venous systems, whereas the venous angioma, which is often calcified, remains stationary unless there is haemorrhage from it.

Both these types are encountered mainly above the tentorium. Associated with a venous angioma of one hemisphere there is often a naevus upon the face of the same side.

The haemangioblastoma is a true neoplasm and is benign. It occurs almost invariably in the cerebellum. It is composed of reticulin fibres and endothelial cells forming capillary or cavernous spaces and undergoing lipoid degeneration. Cyst formation is common. Lindau has shown that it may be associated either in the same person or in families with angioma of the retina (von Hippel's disease) and other lesions.

Incidence

The frequency of the blood-vessel tumours is 4·2 per cent. The venous and arteriovenous angiomas, being congenital, may produce symptoms in early life, but may be encountered at any age. The haemangioblastoma is a tumour of adult life. The venous and arteriovenous angiomas do not lend themselves to surgical removal, but the removal of a haemangioblastoma of the cerebellum carries a low operative risk, except when the tumour is entirely solid, or the mural nodule of a cyst is difficult of access.

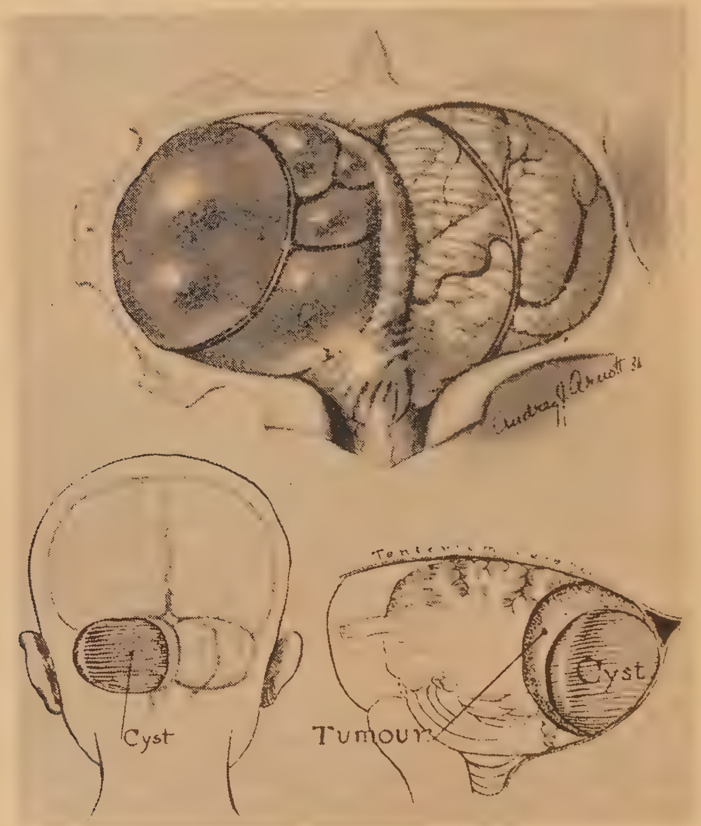


FIG. 104.—Cystic and solid astrocytoma of left cerebellar lobe

(*f*) *Non-Malignant Gliomas*

Before we proceed to the category of malignant tumours we must consider separately certain of the gliomas, for a few of these tumours, contrary to older belief, appear to be in every sense benign.

As a group, the gliomas constitute probably 50 per cent of all intracranial tumours. They are composed of neuroglial elements and are roughly divisible into those whose cells are undifferentiated, resembling the primitive neuroglial cells of the embryo, and those whose cells are of adult type. It is in the latter group that the benign gliomas occur.

Cerebellar astrocytoma

The cerebellar astrocytoma is the most important member of the group (see Fig. 104). With rare exceptions it is a circumscribed tumour, often cystic, of slow growth, and situated rather more often in the vermis than in one lateral lobe. It is entirely composed of fibrillary and protoplasmic astrocytes. Its frequency is 4·4 per cent. It is essentially a tumour of childhood, occurring most frequently between the ages of 5 and 15. The case mortality in 29 cases of Cushing's recent series was 3·4 per cent.

Ependymoma

Another benign glioma is the ependymoma of the fourth ventricle. The character of some other gliomas which appear to be benign is not yet sufficiently well defined to warrant separate description.

(*g*) *Other Non-Malignant Tumours*

Less common benign tumours are colloid cysts of the third ventricle, cholesteatoma (dermoid), chordoma, papilloma of the choroid plexus, teratoma and chondroma.

(2)—Malignant Tumours

These tumours as a whole are of rapid growth, invasive, and tend to recur quickly after removal.

(*a*) *Spongioblastoma multiforme*

The commonest variety is the spongioblastoma multiforme (see Fig. 105). These are large vascular tumours of rapid growth, often containing areas of necrosis and multiple cysts. They are ordinarily found in the white matter of the cerebral hemispheres and corpus callosum, and are surrounded by a wide area of oedema. Histologically the tumour consists of undifferentiated glia cells and its blood-vessels show degenerative changes.

Incidence

Its frequency was 22 per cent of the whole series of tumours already referred to. These are essentially tumours of adult life and are especially common after the age of forty.

(*b*) *Medulloblastoma*

These are soft rapidly-growing tumours found in the cerebellar vermis and extending into the lateral lobes, and sometimes into the subjacent brain-stem. They frequently give rise to metastases by way of the cerebrospinal fluid channels, perhaps most commonly in the meninges of the spinal cord, but also on the surface of the brain and in the ventricular system. They are composed of spherical and oval cells arranged in compact masses. They have a characteristic appearance in supravital preparations. *Incidence* Their frequency is 3·3 per cent. The tumour occurs most frequently in childhood, but may be encountered in early adult life up to the age of thirty.

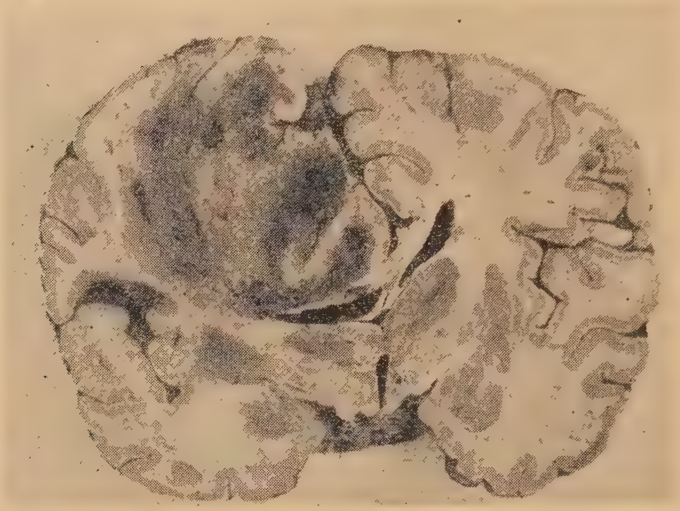


FIG. 105.—Spongioblastoma multiforme of left parietal lobe extending into the corpus callosum

(c) *Astrocytoma*

The cerebellar astrocytomas have been described separately on account of their benign character. Astrocytomas elsewhere are for the most part infiltrating in character and tend to recur after removal. They may occur in any part of the cerebral hemispheres, corpus callosum, mid-brain and pons. They are relatively non-vascular tumours of slow growth with a tendency to cyst formation and often to calcification. Their histological character as a rule differs from that of the cerebellar astrocytomas inasmuch as the tumour contains, in addition to the astrocytes, oligodendroglia cells, spongioblasts, and other less well differentiated neuroglial elements. *Incidence* Their frequency is 7·2 per cent. These are tumours of adult life and are perhaps more common in the earlier years. Cushing's case mortality for 70 patients was 4·2 per cent. The late results, however, in a series of 15 cases showed fatal recurrence in all except one within a period of 10 years.

(d) *Other Gliomas*

Among the other gliomas the only two of common occurrence are the astroblastoma and oligodendroglioma. These are both supratentorial tumours of adult life. They are of slow growth but tend to recur after removal. The oligodendroglioma is frequently calcified.

(3)—Metastatic Tumours

Metastatic tumours comprised 8·5 per cent of the series mentioned above. The lung, breast and kidney are the most common sites for the primary lesion which may sometimes be inconspicuous. In the brain as in other organs, metastases are multiple more often than solitary. The centrum semiovale and the cerebellar vermis are the most common sites; occasionally, the neoplastic process is limited to the pia-arachnoid. Metastatic tumours are connected very loosely with the surrounding brain. Cyst formation is common. Rapidly-growing tumours in the middle or posterior fossa sometimes arise by direct spread from a squamous carcinoma of the nasopharynx.

Distribution

3.–CLINICAL PICTURE

The symptoms which may result from cerebral tumour are multitudinous, and are to a large extent covered by the articles in these volumes dealing with BRAIN: REGIONAL DIAGNOSIS, EPILEPSY, and HYDROCEPHALUS. For practical purposes it is the early symptoms which are important and it is with these and with their evolution that we are chiefly concerned. The early symptoms of cerebral tumour may be grouped as follows:

(1)—Hydrocephalic Symptoms

These, of which the most common are headache, vomiting, papilloedema and drowsiness, may be the first symptoms to be observed, in two important groups of tumours. The first is that in which the tumour —by virtue of its situation rather than its size—causes direct obstruction to the outflow of cerebrospinal fluid from the ventricular system. Such are tumours arising from the walls of the ventricles, and tumours of the cerebellum (especially in its middle lobe), which press directly upon the roof of the fourth ventricle. The second group comprises supratentorial tumours so placed that they may, as the combined result of their own volume, oedema of the surrounding brain, and secondary hydrocephalus, cause symptoms of increased intracranial pressure without other signs. Tumours in the frontal region, and to a lesser extent in the temporal and posterior parietal regions, may first manifest themselves in this way, more often (in right-handed persons) on the right side than on the left, since a left-sided tumour in these regions may result in the appearance of dysphasia as an earlier symptom. In the later stages of hydrocephalus a number of symptoms may occur as the result of increased intracranial pressure, such as paralysis of the cranial nerves (especially the sixth pair), extensor plantar responses, loss of the deep reflexes, epileptic attacks—focal or generalized.

Early symptoms

(2)—The Localizing Effects of a Gradually Progressive Lesion

A gradually progressive lesion may involve the motor, sensory or visual fibres, or speech areas, in the brain; the nuclei and tracts of the brain stem; or the cerebellum. The symptoms produced are many and various. They are those of a focal lesion (see BRAIN: REGIONAL DIAGNOSIS); but it is not the character of the symptoms which is important as evidence of tumour, so much as their gradually progressive evolution, throughout a period of weeks or months. Occasionally, as the result of a sudden access of oedema, the development of symptoms may be rapid, or, in the rare case of haemorrhage within a tumour, sudden. A great many tumours reveal their presence by causing focal symptoms before those of increased intracranial pressure develop.

Lesion of optic nerves

A gradually progressive lesion of the optic nerves, chiasma or tracts causes as an early symptom, failing vision. Later there is optic atrophy, but vision may be gravely impaired before there is much pallor of the discs. Diagnosis rests upon the recognition of characteristic defects in the visual fields, which can always be found by quantitative perimetry as soon as visual symptoms appear. Involvement of one optic nerve results, of course, in failure of vision in that eye. Loss of one or both temporal fields is characteristic of the chiasmal lesions, and a contralateral homonymous defect results from a lesion of one optic tract.

Pressure on optic nerves

Pressure upon one or both optic nerves, or the optic chiasma, is of almost constant occurrence with pituitary adenomas, and is common with the hypophysial duct tumours, and the midline meningiomas of the anterior fossa (suprasellar and olfactory groove meningiomas). Occasionally an intracranial aneurysm may produce the same effects.

A small meningioma arising from the lesser wing of the sphenoid close to the optic foramen may cause unilateral blindness and optic atrophy.

Pressure upon one optic tract may sometimes result from a pituitary adenoma, but is more likely to be due to a tumour in the anterior part of the temporal lobe, or a hypophysial duct tumour.

The associated symptoms to be looked for are, in the case of the meningiomas of the anterior fossa, anosmia: and in the pituitary or hypophysial duct tumours symptoms of dyspituitarism. The pituitary adenoma never in its early stages causes hydrocephalic symptoms (generalized headache and papilloedema) whereas any of the other tumours is apt sooner or later to do so.

(3)—Epileptic Attacks

Tumours pressing upon, or invading the cerebral cortex, may give rise to epileptic attacks for weeks, months or years before any other symptom develops. The attacks may be major or minor in degree, and focal or generalized in character according to the situation of the tumour.

Significance of epileptic attacks

Any kind of tumour may cause epileptic attacks as its earliest symptom. A history of such attacks occurring for a year or more before other symptoms develop is always suggestive of a slow-growing glioma (cerebral astrocytoma, oligodendroglioma) or meningioma. In this group the gliomas outnumber the meningiomas by two to one. The meningiomas, being more often situated along the line of the sagittal sinus or in the Sylvian fissure, cause focal attacks of a motor and sensory character more often than the slow-growing gliomas.

(4)—Progressive Dementia

This is a not uncommon symptom as a late result of increased intracranial pressure, but we are here concerned with the mental changes which, in a considerable number of patients with supra-tentorial tumours, may precede all other symptoms, and first lead the patient, or his relations on his behalf, to seek medical advice. The early symptoms of this nature are failing attention and memory, especially for recent events, lack of initiative, defective power of concentration, faulty judgement, apathy and deterioration of the personality. The patient may become careless and uninhibited in his talk and manners, and slovenly in his habits. In the development of this clinical picture there may be fluctuations, and occasionally acute episodes, taking the form, for instance, of uncontrolled excitement.

Localization of lesions

The tumours which present in this fashion are for the most part deeply-seated gliomas in the frontal lobes and temporal lobes and tumours of the corpus callosum; the majority are spongioblastomas.

(5)—Disorder of the Endocrine and Vegetative Functions

Sexual disturbance

Disturbance of the reproductive functions, manifested by amenorrhoea in the female and impotence in the male, is one of the earliest symptoms of all varieties of pituitary adenoma, and is common also in supra-pituitary tumours, such as hypophysial duct tumours, and gliomas of the floor of the third ventricle and optic chiasma. In females of the child-bearing period with acromegaly, persistent lactation is not infrequent. Sexual precocity has been recorded as the most conspicuous symptom of pineal tumours and of tumours of the region of the corpora mammillaria (see also Vol. I, pp. 214 and 246).

Disorders of growth

Excessive growth is characteristic of acidophil pituitary adenomas, taking the form of acromegaly in the adult and gigantism in the young. Diminution of, or cessation of growth is almost invariable in children with hypophysial duct tumours, and in the rare cases of chromophobe pituitary adenoma in children. These patients are dwarfs of perfect symmetry and build, in contrast with achondroplasic dwarfs and cretins, and in most cases their epiphyses remain ununited as long as they live, even into the fourth decade. The other alterations of outward appearance that occur in acromegaly and gigantism are described elsewhere (see Vol. I, p. 166, and PITUITARY GLAND DISEASES).

Chromophobe pituitary adenomas produce little change in outward appearance, but in the male a change towards the feminine type of habitus is often noticeable. The appearances of pituitary cachexia are occasionally seen in chromophobe pituitary adenoma and hypophysial duct tumour of long standing.

Obesity

Gross obesity is rare in intracranial tumours and is then usually associated with a tumour of the floor of the third ventricle. Obesity with a chromophobe pituitary adenoma is usually of mild degree. Glycosuria and hyperglycaemia are found at some stage of the illness in 25 per cent of patients with acromegaly and may be the first symptom of colloid cyst of the third ventricle. Hypersomnia and polyuria may be the leading symptoms of tumours compressing or invading the floor of the third ventricle.

It will be observed that most of the symptoms described in this section are characteristic of tumours situated in or above the sella turcica. All, however, with the exception of excessive growth and sexual precocity, may be caused by distension of the third ventricle as the result of long-standing hydrocephalus, as for instance from a slow-growing glioma of the cerebellar vermis.

(6)—Localized Headache

This sometimes appears as an early symptom without evidence of increased intracranial pressure. A superficial tumour of the brain may cause localized neuralgic pain, usually associated with tenderness. The meningiomas are especially apt to produce this symptom, and it is seldom absent when the tumour invades the skull. Tumours of the posterior fossa, especially those in the neighbourhood of the foramen magnum, often present pain in the suboccipital region and back of the neck as an early symptom. Associated with this there is sometimes localized tenderness, and some degree of cervical rigidity.

The pituitary adenomas are apt to cause bitemporal or bifrontal pain of a boring character and often severe.

(7)—The Syndrome of the Cerebello-Pontine Angle

Sequence of symptoms

Tumours in this situation, of which the acoustic tumour is the commonest, produce a characteristic sequence beginning with affection of the cranial nerves, and ending with hydrocephalus and symptoms of pressure upon the pons and medulla. In the acoustic tumour the first symptoms are deafness, usually asssociated with tinnitus, and sometimes with attacks of vertigo. As a rule the next cranial nerve to be affected is the fifth, leading to loss of the corneal reflex and paraesthesiae in the trigeminal field. Weakness of the face, often remarkably slight, and paralysis of the sixth, and sometimes of the ninth, tenth, eleventh and even the twelfth cranial nerves, follow.

(8)—Bruit

A bruit in the skull, sometimes audible to the physician alone, sometimes also to the patient, may be present with any superficial and extremely vascular tumour, and is a conspicuous feature of the arteriovenous malformations. It is rare with aneurysm of the cerebral arteries. In children with tumour and hydrocephalus a bruit can usually be heard over the main venous sinuses, no matter what the nature of the tumour. In infants below the age of two a bruit in the head is without pathological significance.

(9)—Swelling

A visible or palpable swelling on the head may sometimes be the first evidence of an intracranial tumour—meningioma, sarcoma or secondary growth. Localized expansion of part of the skull may occur occasionally in young children from a slowly-growing tumour beneath it. Tumours at the base of the brain may sometimes project into the nasopharynx.

4.–SPECIAL METHODS OF EXAMINATION

(1)—Examination of the Cerebrospinal Fluid

Indications for puncture

Although lumbar puncture in certain cases of intracranial tumour is not without risk, the information derived from the cerebrospinal fluid is so often of value that it is only in exceptional cases that this examination should be omitted. The greatest danger is in cases with a high degree of intracranial pressure, as shown by the clinical signs. In such cases puncture should be performed, if at all, only as an immediate preliminary to operation. In any case the quantity of fluid withdrawn should be the minimum required for examination—2 to 4 c.c. should suffice.

Pressure

The pressure of the cerebrospinal fluid as taken by the manometer, although not always a reliable guide to the intracranial pressure, sometimes yields valuable information. A pressure higher than 200 mm. of water, with the patient relaxed in the horizontal position, is evidence of a pathological increase of intracranial pressure, and may be found before headache or papilloedema has developed. Conversely a normal pressure may occasionally be found in a patient presenting these symptoms.

Protein content

The protein content of the fluid (normal, 20 to 40 mg. per 100 c.c.) often yields valuable information when taken into account with other features of the case. A high figure is almost invariably obtained with basal meningiomas (average, 150 mg. per 100 c.c.) and with acoustic tumours (average, 200 mg. per 100 c.c.). It is common also with large vascular gliomas of the cerebral hemisphere, especially if the tumour is close to one of the ventricles. In these cases the protein content of the ventricular fluid is much higher on the side of the tumour than on the opposite side. With other types of tumour the protein as a rule is slightly increased or normal.

Cell count

The cell count is usually normal (2·5 per c.mm.). In tumours which invade the meninges or the walls of the ventricles, there may be a slight increase, usually restricted to lymphocytes. In tumours with large and recent areas of necrosis (spongioblastoma multiforme), the fluid may occasionally contain a large number of cells (1,000 or more per c.mm.) with a preponderance of polymorphonuclear leucocytes. Tumour cells may sometimes be found in carcinomatosis of the meninges, medulloblastoma and other malignant tumours.

Wassermann reaction

The Wassermann reaction should be tested as a routine whenever a sample of cerebrospinal fluid is taken. In gummatous meningitis it may be positive in the fluid while negative in the blood.

(2)—X-Ray Examinations

Abnormalities in radiographs

X-rays of the skull with modern technique yield positive information in 30 to 40 per cent of cerebral tumours. A complete set of stereoscopic pictures, taken in standard position, is necessary. The more important changes to be looked for are as follows:

Calcification. About 10 per cent of intracranial tumours contain some calcium, either scattered diffusely or in one small part of the tumour. The tumours most commonly showing calcification are gliomas (especially oligodendroglioma, cerebral astrocytoma and occasionally spongioblastoma multiforme), tumours of the hypophysial duct, and meningiomas. Calcification is also seen in tuberculomas, teratomas, angiomatous malformations, cysticercosis and old haemorrhages. It should be borne in mind that intracranial calcification of the dural envelope and partitions, the choroid plexuses, pineal body and large intracranial arteries is not usually of pathogenic significance.

Vascular Changes. With meningiomas and other tumours attached to the dura the neighbouring meningeal vessels are usually enlarged. This can be seen radiographically in the form of a symmetrical increase in the number and size of the meningeal grooves. The X-ray films should be stereoscopic and of the highest quality.

Invasion

Changes in the Skull. Intracranial tumours sometimes invade the skull, especially meningiomas, sarcomas and some secondary carcinomas. A local swelling of the skull (hyperostosis) may or may not follow, but radiograms will always show local changes of bone texture. Sometimes the area invaded shows increased density indicating an osteogenic reaction of the bone to invasion by tumour; in other cases the density of the invaded bone is diminished, indicating an osteoporotic action. The factors that govern deposition and resorption of bone are not yet understood. The type of bone reaction in response to invasion is no indication of the pathological type of the tumour.

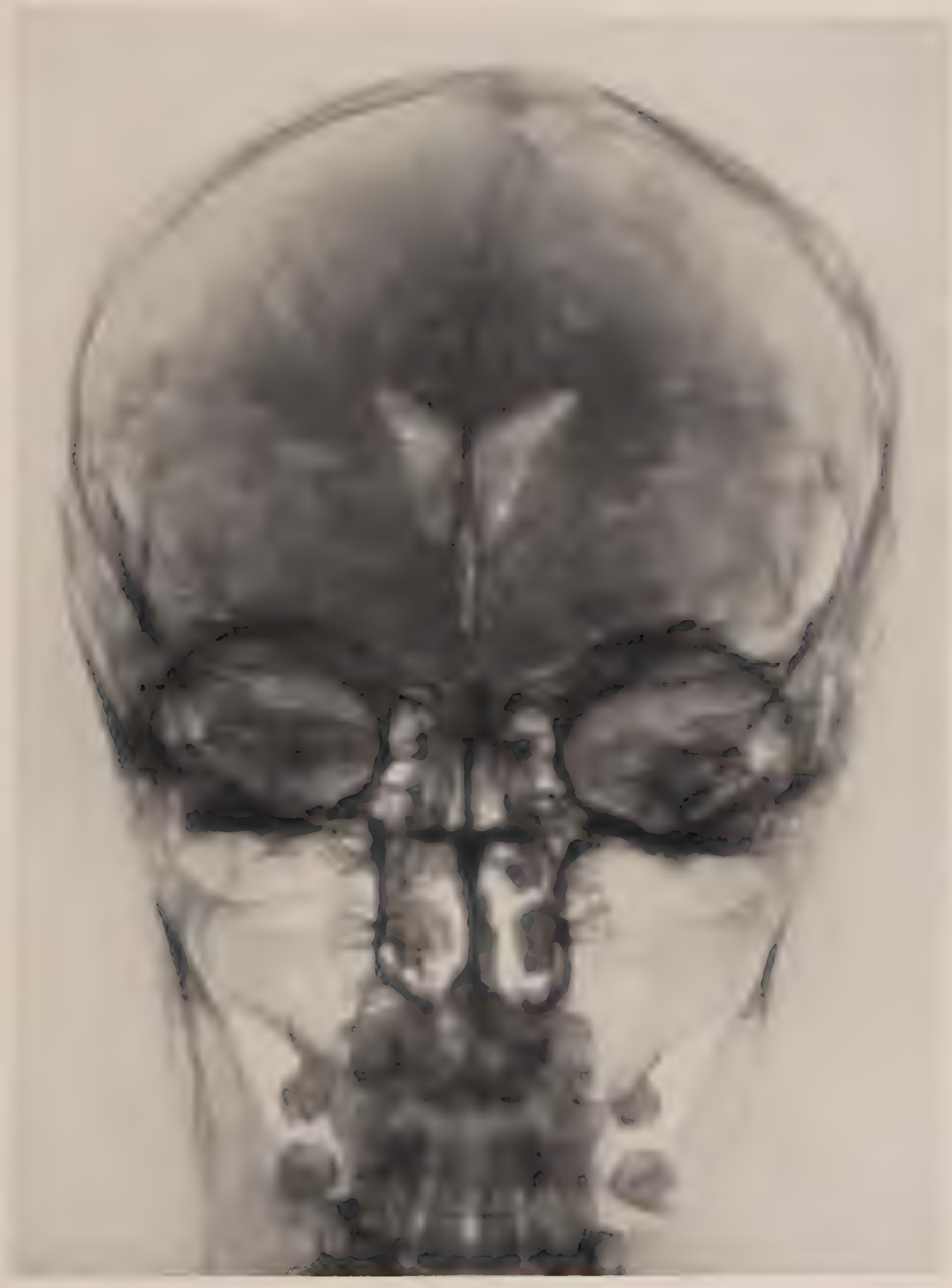
Thinning

Intracranial tumours sometimes produce local thinning and even expansion of the skull without invasion. This can be seen radiologically.

Endostosis

At the point of attachment of dural meningiomas there is sometimes a small projection of the skull into the intracranial cavity (endostosis). This valuable radiological sign is best seen in tangential views.

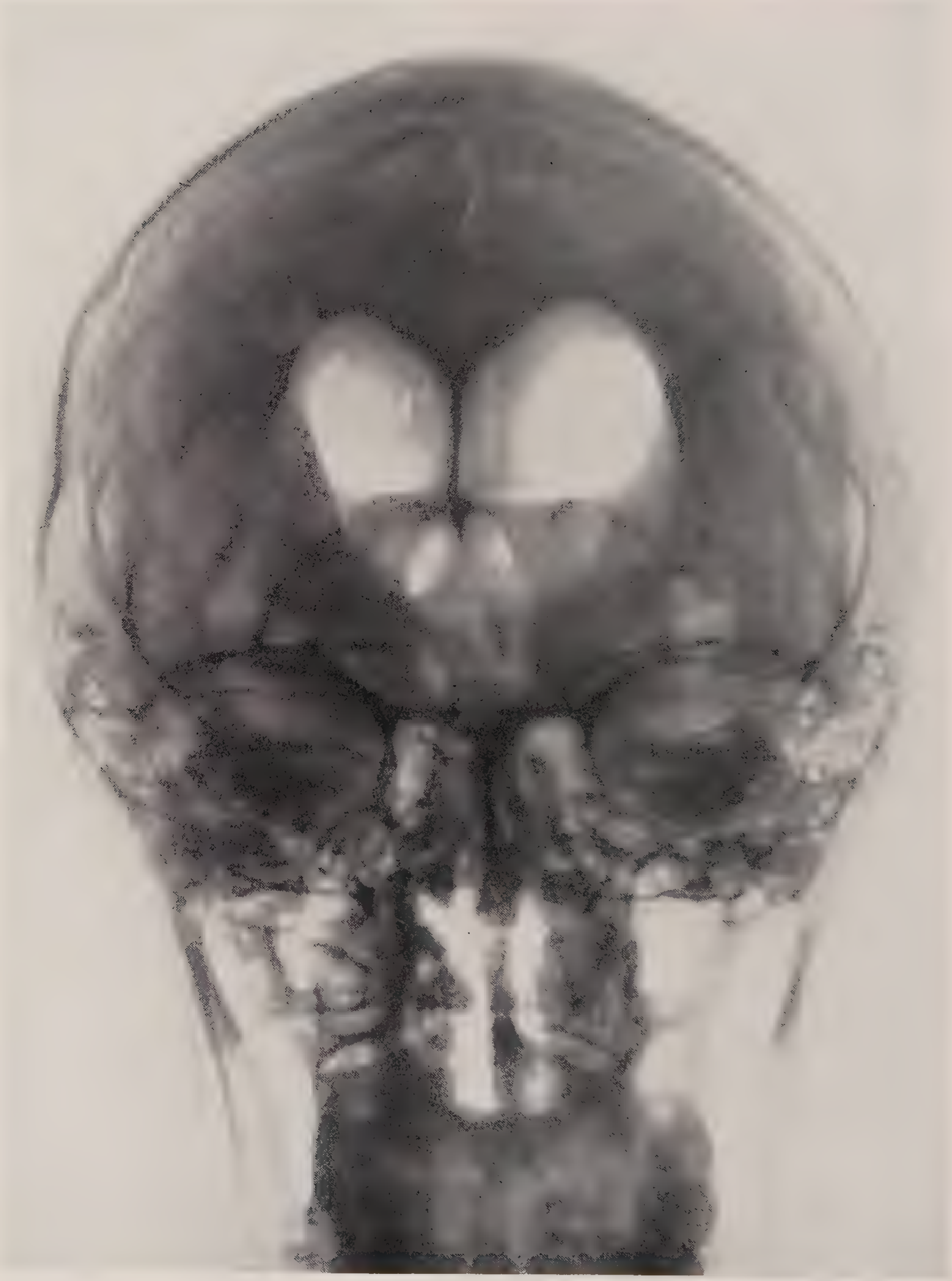
Changes in the sella turcica and adjacent parts. The sella is expanded by intrasellar tumours and by long-continued pressure from a dilated third ventricle. Aneurysms of the circle of Willis, besides showing at times an arc or ring of calcification, may also deform the sella. The optic foramen, which can be accurately examined with suitable pro-



Normal antero-posterior ventriculogram (air in lateral and third ventricles and in fissures of the brain)

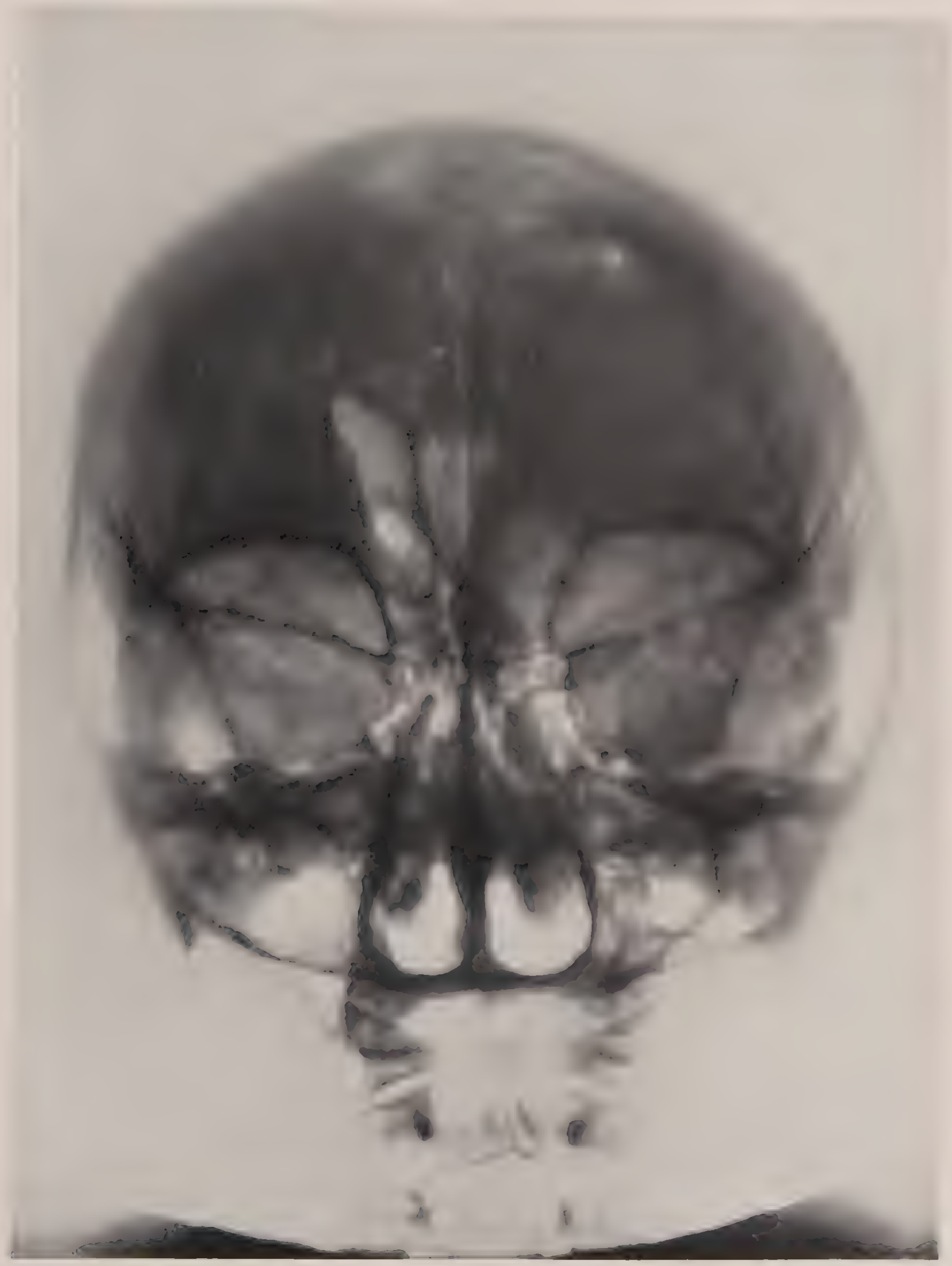
PLATE IX

[*To face p.* 632



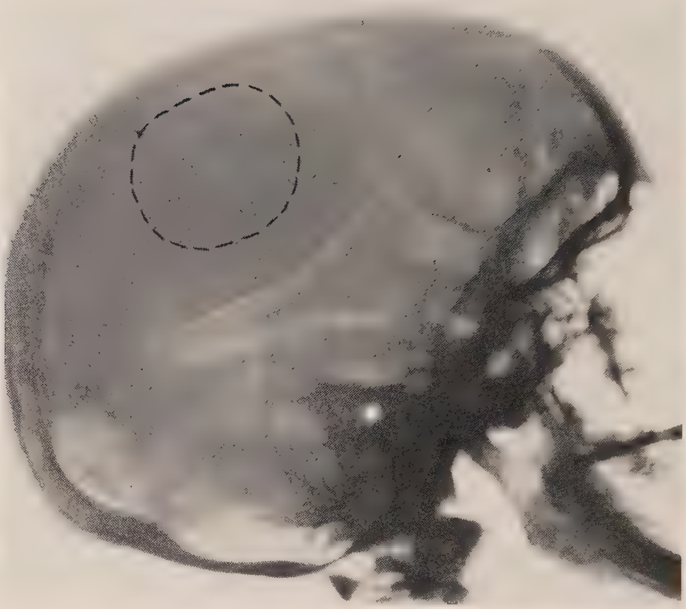
Hydrocephalus due to tumour of mid-brain. Dilated lateral and third ventricles

Plate X

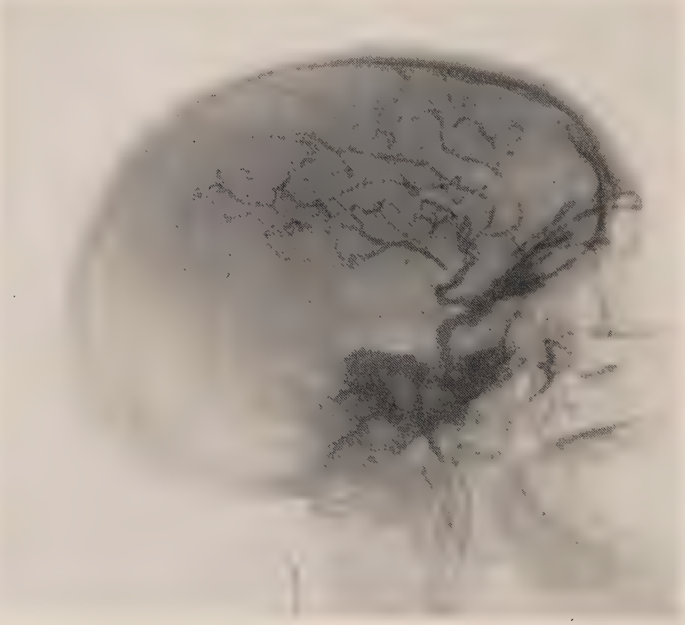


Tumour of left occipital region. Lateral and third ventricles displaced to the right

Plate XI



A.—Tumour of cerebral hemisphere (dotted line) causing depression of body of corresponding ventricle



B.—Normal arteriogram

PLATE XII

[*To face p.* 633

jections, is also pathologically altered in shape and size by tumours in its neighbourhood.

Rise of Intracranial Pressure. This shows itself radiologically in children by separation of the sutures and expansion of the head, and in adults by increase of the normal convolutional markings of the skull and by changes in the sella turcica.

(3)—Ventriculography and Encephalography

With few exceptions intracranial tumours produce deformity of the ventricular system. Tumours in the posterior fossa produce dilatation of the third and lateral ventricles; tumours of the third ventricle produce symmetrical dilatation of the lateral ventricles, but deform or obliterate the third ventricle. A tumour in one cerebral hemisphere causes displacement of the lateral and third ventricles towards the opposite side; the lateral ventricle on the side of the lesion tends to become collapsed, while that on the opposite side is usually dilated.

Technique

These facts are utilized in topographic diagnosis of intracranial tumours which do not give unequivocal clinical signs of their localization. Air or oxygen can be injected into the ventricles by puncture of the brain through small burr holes (ventriculography), or through lumbar puncture with the patient in the erect position (encephalography). It is quickly absorbed from the subarachnoid space, most of it disappearing within the first 24 hours, but neither method is free from risk of severe rise of intracranial pressure. Encephalography is the more dangerous and is reserved for cases in which intracranial pressure, as indicated by the clinical signs, is not seriously raised. The dangers of ventriculography are usually averted by immediate operation on the tumour, or by withdrawing the air from the ventricles as soon as the radiograms have been studied.

Lipiodol and thorotrast have been used for ventriculography in place of air. Although they give greater radiographic detail of the ventricles their use is attended by greater risk, since they produce a sharp inflammatory reaction of the ventricular walls.

(4)—Ventricular Estimation

Tapping of ventricles

In patients who are comatose from rise of intracranial pressure, or otherwise so severely ill that ventriculography is likely to affect seriously the chances of a successful operation, information of much value can be obtained by tapping the lateral ventricles and estimating their position and size from the amount of fluid obtained and the depth at which it is tapped. If both lateral ventricles are dilated the tumour is in the third ventricle, mid-brain or posterior fossa. If one lateral ventricle is small, while the other is normal in size or enlarged, the tumour is on the side of the collapsed ventricle.

This method can always be used as a preliminary to any major operation for intracranial tumour without any technical difficulty or serious delay. It provides a useful control of clinical diagnosis and the withdrawal of fluid from the ventricles may assist considerably by reducing pressure in the early stages of the operation. Furthermore, occasionally the needle exploring for the ventricle encounters a cyst or solid tumour.

(5)—Cerebral Angiography

Thorotrast and other opaque substances are injected into the carotid artery and a series of lateral X-rays of the skull is immediately taken. In a successful injection the first pictures show the cerebral arterial tree on the side of the injection, and the later ones show the main venous sinuses. The situation of the tumour may be shown by the presence of abnormal vessels or a diffuse cloud of thorotrast in the capillaries of a tumour; or by the displacement of the main branches of the internal carotid. The method is particularly valuable in providing the pathological as well as the localizing diagnosis when vascular tumour or aneurysm is suspected.

Indications

(6)—Brain Puncture

When a malignant type of tumour is suspected, the diagnosis can sometimes be confirmed by microscopic examination of tiny fragments of tissue removed through a brain needle. The tissue is prepared for histological examination by the method of Dudgeon and Barrett and is stained with toluidin blue or Mann's stain.

5.–PROGNOSIS

The symptoms of intracranial tumours are progressive to a fatal issue unless relieved by operation. An exception to this rule may be made in the case of the venous angioma, a congenital malformation which does not increase in size except as the result of haemorrhage within or from its substance. The arteriovenous angiomas also may be so slow in their development that they do not appreciably shorten life, and the same may be said of a number of the pituitary adenomas.

Causes of death

Tumours which involve the vital or vegetative centres in the medulla or floor of the third ventricle may cause death from their local effect, and this may be sudden. In all other cases the cause of death is indirect, from increased intracranial pressure, which eventually deprives the medullary centres of their blood supply.

Drowsiness, periodic respiration, repeated vomiting and a slowing pulse are the most important signals of impending death, but after the first phase of this kind there is not infrequently a remission.

Prognosis in subtentorial tumours

In subtentorial tumours severe paroxysmal pain in the back of the neck is of grave import even in the absence of the usual signs of hydrocephalus.

In suprasellar tumours

The pituitary and suprasellar tumours cause blindness with primary optic atrophy long before they threaten life. Loss of vision from secondary optic atrophy not infrequently occurs as the result of increased intracranial pressure from slow-growing tumours (meningioma, cerebellar astrocytoma, acoustic tumour, colloid cyst of third ventricle, cerebral astrocytoma) at a stage when the patient may yet have many months or even years to live.

In spongioblastoma multiforme

The spongioblastoma multiforme, whatever its situation, is the most rapidly-fatal tumour, death occurring as a rule within a year of the first appearance of symptoms, and in many cases within only a few months after the diagnosis has been established. The metastatic tumours are often equally rapid in their progress. In both these types of tumour apathy and stupor may develop at a rate which appears out of proportion to the degree of intracranial pressure, and is probably due to oedema of the brain surrounding the growth.

In medulloblastoma

The medulloblastoma also is rapidly fatal from hydrocephalus, the average duration of life being about a year from the time when the diagnosis is first made, unless relief is given by means of decompression and radiation. The cerebral astrocytomas are usually of slow growth and it may be several years before they lead to a fatal issue.

In benign tumours

Of the benign tumours the most dangerous are those which on account of their situation cause a rapid development of hydrocephalus. A cerebellar astrocytoma in the vermis therefore may prove fatal within a year of the first appearance of symptoms. On the other hand if situated superficially in one of the lateral lobes it may be compatible with many years of life.

In blood-vessel tumours

Of the prognosis in the blood-vessel tumours some indication has already been given. The venous angiomas are as a rule non-progressive, the arteriovenous tumours slowly so. The haemangioblastomas may be slowly progressive over a period of a year or two but then on account of their subtentorial situation cause rapidly fatal hydrocephalus.

In meningiomas

The meningiomas are usually compatible with life for several years. An acoustic tumour may cause no serious effects for four or five years from the first auditory symptoms but the development of hydrocephalus is often sudden.

In hypophysial duct tumours

The history of the hypophysial duct tumours also is spread as a rule over several years before there is any danger to life.

In pituitary adenoma

Of all intracranial tumours the pituitary adenoma is slowest in its rate of growth. The patient may live as long as twenty years after vision has been lost.

Mortality

The mortality rate for operation in removable tumours has been indicated under the heading Pathological Classification (p. 621).

Prognosis after operation

The after-results of operation with regard to working capacity and usefulness of life have recently been investigated by one of us (H. C.) in a series of 157 patients operated upon by Cushing. Sixty-three of this series were alive seven to nine years later, and of these 37, roughly one in four of the original patients, were living a useful life. All the patients with spongioblastoma multiforme (8 cases) and cerebellar medulloblastoma (5 cases) died within the first two years after operation from recurrence of tumour. All the patients with metastatic tumour (8 cases) died within the first three years. Of 15 patients with cerebral astrocytoma only one was alive at the time of the investigation, the majority having died within the first three years after operation.

The 3 patients who survived removal of a cerebellar astrocytoma were all in perfect health seven to nine years after operation. Blood-vessel tumours and hypophysial duct tumours were not well represented in this series; those who survive complete removal of these tumours enjoy as a rule a useful life. Of 9 patients with acoustic tumours who survived the operation of intracapsular removal of the tumour only two were living a useful life, the others being incapacitated by persistent ataxy. On this account the surgical trend is towards complete removal of the tumour, despite the greater risk.

Of the 26 patients who survived removal of a meningioma 8 died later from recurrence owing to incomplete removal of the tumour; the remaining 18 were alive seven to nine years after operation, 14 of them able to work and 4 of them incapacitated from various causes. A few of the workers suffered from major symptoms, epileptic seizures, loss of vision and so forth.

There were 28 survivors of operation for pituitary adenoma. Nine died in later years, and the majority of the others were in full work seven to nine years after operation and had reading vision in one or both eyes.

6.–DIFFERENTIAL DIAGNOSIS

From other causes of hydrocephalus

The hydrocephalic symptoms of cerebral tumours have to be distinguished from those of hydrocephalus arising from other causes, for instance, meningitis, otitis media and trauma; from the symptoms of increased intracranial pressure which may occur in some cases of cerebral syphilis; and from comparable symptoms in cases of cerebral abscess, and chronic subdural haematoma. Analysis of the history of the case together with examination of the cerebrospinal fluid and blood will as a rule prevent an error in diagnosis, but it should be remembered that a cerebral tumour may co-exist with syphilis. Chronic subdural haematoma is the condition most likely to offer difficulty in diagnosis and the question may only be settled by exploration or in the process of ventriculography.

From hypertension

Headache, vomiting and papilloedema may sometimes be encountered in arterial hypertension, and the cerebrospinal fluid in these cases may be under increased pressure (up to 400 mm. of fluid). The blood-pressure, and especially the diastolic pressure, which is usually above 130 mm. Hg, provides the clue to diagnosis.

From encephalitis

In certain rare forms of encephalitis (disseminated encephalomyelitis, Schilder's encephalitis) the optic discs may be swollen as the result of papillitis which together with other cerebral symptoms may suggest tumour. In these cases the changes in the discs are associated from the onset with severe visual defect. Among other conditions which produce papilloedema and thus may simulate intracranial tumour are subarachnoid haemorrhage and polycythaemia vera.

From progressive focal lesions

Tumours which begin with symptoms of a progressive focal lesion must be distinguished from a number of conditions, of which the most important are in young persons disseminated sclerosis, in the middle-aged cerebral syphilis, and in the elderly cerebral thrombosis. In thrombosis the rate of onset of the symptoms is more rapid than in tumour, unless, as may occur, there is haemorrhage into a vascular growth.

From idiopathic epilepsy

When epileptic attacks are the earliest symptoms the differential diagnosis from idiopathic epilepsy and from other causes of epilepsy such as syphilis may require full investigation. In the case of an adult presenting epileptic attacks for the first time and with a negative family history, cerebral tumour should always be suspected.

From other causes of optic atrophy

Failing vision with optic atrophy may be caused by syphilis, glaucoma, tobacco poisoning, disseminated sclerosis and some hereditary diseases (juvenile form of Tay-Sachs disease, Leber's optic atrophy)—causes which as a rule are easily distinguished from tumour, especially if the visual fields are thoroughly examined.

From other conditions

The cases of tumour in which progressive dementia is the leading symptom have to be diagnosed from dementia paralytica, cerebral arteriosclerosis, and from the presenile dementias. The acoustic tumours in their early stage have to be distinguished from other causes of unilateral nerve deafness. The involvement of other cranial nerves, especially the fifth, provides the clue to diagnosis. Syphilis in the cerebello-pontine angle may produce comparable symptoms.

7.—TREATMENT

(1)—Hypertonic Solutions

The rise of intracranial pressure produced by intracranial tumours can be temporarily relieved by the use of hypertonic salt solution. The most rapid effect is obtained by intravenous injection of 15 per cent sodium chloride or 50 per cent glucose (50 to 100 c.c. for an adult); after such an injection a patient with signs or symptoms of tumour, who is in coma when first seen, will usually recover consciousness for long enough to co-operate in neurological examination, but the beneficial effect of hypertonic salt is short-lived and intravenous injections should be soon followed by operation. Less dramatic but useful reduction of intracranial pressure can be obtained by the use of magnesium sulphate by mouth or by rectum.

(2)—Operation

Indications

Save in cases of extreme urgency operation for intracranial tumour should not be undertaken until a precise localizing diagnosis has been made. The methods of modern cranial surgery cannot be described in detail here, but they include various devices for careful haemostasis, among them the high-frequency current, the use of local anaesthesia whenever the patient has high rise of intracranial pressure, irrigation with Ringer's solution, and suction.

General principles

Of the principles that should govern all operations for removal of intracranial tumour, the first is that the surgeon should study thoroughly the case and the patient before he plans the details of his operation. The exploration should not be of stereotyped pattern but should be designed in each individual case to give the best possible exposure of the diseased area. During the operation every effort should be made to avoid irreparable damage to the brain in exposure and removal of the tumour. In deeply-placed tumours it may be necessary to excise parts of the overlying brain in order to expose the tumour. The anterior part of the frontal lobe, the right temporal lobe and the cerebellum can be resected without producing serious damage, and even in other parts the ultimate functional result may sometimes be better if cortex is resected and the tumour radically removed, in preference to preservation of the cortex and palliative decompression. However, interference with the precentral gyrus, the parietal lobes and the left temporal lobe almost invariably produces permanent disability of a serious degree.

Palliative decompression

The operation of palliative decompression may produce undesirable results if applied indiscriminately, the chief of which is prolongation of a fatal illness in malignant tumours. Surgical interference on account of malignant tumours is rarely called for, as has been indicated in the foregoing pages, but if such a tumour is encountered at operation in a case in which the type of the tumour, whether malignant or benign, cannot be determined by other methods, the least unfavourable ultimate result will usually be obtained by radical removal of the tumour and firm closure of the skull.

Palliative decompression still has a place in intracranial surgery as the first stage of a more radical operation on the tumour, or for the relief of high pressure in slowly-growing tumours of the basal ganglia and other inaccessible parts, when it should be followed by radiation therapy. Cerebellar decompression is particularly valuable as a first stage operation for preservation of sight in tumours of the posterior fossa, although if vision is already seriously reduced nothing short of radical removal of the tumour will be of value. Bony decompressions should only be performed in regions of the skull that are covered by muscle. The relief of pressure is only slight unless the dura is opened. All wounds should be firmly closed in several layers.

Trans-sphenoidal decompression is a useful procedure in certain cases of pituitary adenoma, especially in elderly people, who sometimes develop mental symptoms if treated by the more usual frontal osteoplastic exploration and elevation of the frontal lobe.

Indications and results

Radiation Therapy. For infiltrating tumours which recur after the tumour has been removed (spongioblastoma multiforme, medulloblastoma and other forms of glioma) various forms of radiation have been tried: deep X-ray therapy, radium by cap and bomb, etc. The medulloblastoma responds promptly to any form of radiation for a time with great alleviation of symptoms, but with each subsequent recurrence it becomes more resistant and the tumour ultimately spreads and proves fatal. In other forms of glioma, radiation has not proved so clearly beneficial, although in occasional cases its use after decompression has been followed by long periods of freedom from symptoms. Acromegalic pituitary adenomas may be favourably influenced by radiation, but this should not be used without preliminary operation if the tumour has already produced serious pressure upon the optic chiasm. In arteriovenous angiomas radiation is usually followed by great improvement.

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BRAIN: VASCULAR DISORDERS

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Reference may also be made to the following titles:

ANEURYSM
APOPLEXY
ARTERIAL DISEASE AND DEGENERATION
BLOOD-PRESSURE, HIGH AND LOW
CRANIAL NERVE AFFECTIONS
NEUROSYPHILIS

1.–CEREBRAL ANAEMIA

(1)—General Effects of Cerebral Anaemia

190.] The brain is extremely sensitive to variations in its blood-supply, that is, in the last resort to variations in its oxygen supply, and responds to a falling off in this according to its suddenness, degree and duration. The response may take the form of a transient exaltation of nervous activity—such as is seen in the convulsions of sudden and severe haemorrhage—or in the mental excitability of the milder degrees of anoxaemia. More commonly the response is a diminution of activity, as in the familiar fainting attack.

Of a more severe and permanent character are the apoplexy and hemiplegia which follow arterial occlusion and *local anaemia* of the brain. Indeed, all degrees of variation in functional disturbance, from the simple faint to the fatal apoplexy, may ensue as a result of interference with the free blood-supply to the brain. Even the symptoms associated with an intracranial tumour, or with a depressed fracture of the skull, may be largely due to the vascular disturbances which these lesions cause.

Causes

In brief, anaemia of the brain may be general or local, suddenly or gradually produced, transient or chronic, and it is this variability that is responsible for the protean symptomatology of vascular disorders of the brain. While *general anaemia* of the brain is due to causes remote from the nervous system, such as a blood disease, cardiac weakness or a vasomotor disturbance, *local anaemia* is due to intracranial causes, such as arterial occlusion or rupture, or to a compressing lesion, or—as some believe—to local spasm of the arteries.

(2)—The Fainting Attack (Vasovagal Syncope)

(*Synonym.*—Syncopal attack)

Aetiology

The fainting attack is a common and familiar example of a suddenly produced and transient general anaemia of the brain. It is most frequently seen in the young but may occur at any age. Predisposing factors are fatigue, the fasting state, confinement in crowded or overheated rooms, the debility that may follow illness or infection, severe pain or unpleasant emotional stimuli, such as the sight of blood, or sudden fear. It is important to remember that some of these factors may produce a faint even in a healthy individual. The subject is standing or sitting at the moment of onset, and fainting rarely, if ever, occurs in the supine position.

Symptoms

The essential clinical component of the attack is the syncope or loss of consciousness. Occasionally this may be absolutely sudden, so that the subject falls heavily, but usually there is a sequence of subjective sensations that warn the individual and allow him to sit down or seek support. There is a feeling of 'dizziness' and sometimes of nausea, and a 'sinking sensation' in the abdomen. Hearing and vision are dulled. The subject sweats freely and feels weak. He may sag at the knees. His face becomes pale. The pulse becomes feeble and may be imperceptible; its rate falls to 50 or even less. The blood-pressure also falls to 60, 50, 40 mm. of mercury and even lower, and with this fall consciousness is lost and the muscles become flaccid. The pupils may then dilate, and the respiration take on a sighing character. There may even be convulsive movements of the face and limbs, but these are not forceful and there is never tongue biting or incontinence of urine.

Recovery begins in a few seconds or in a minute or so and may take two or more minutes to complete. The patient remains pale, limp and inert for a variable period, may pass a quantity of pale watery urine and complain of headache.

In a careful study of these attacks, Lewis has noted that there is a slowing of the whole heart and sometimes a type of irregularity characteristic of vagal inhibition. The loss of consciousness is directly due to the great fall in blood-pressure and is vasomotor in origin. We have, then, in the gastric sensations and the slowing of the heart, indications of vagal action, and of vasomotor depression in the fall in blood-pressure and the syncope. In other words, the fainting attack is strictly what Lewis calls it, a vasovagal syncope. He points out that pressure on the carotid (carotid sinus reflex) produces these symptoms, and suggests that the same central mechanism is involved in both cases.

A similar type of clinical picture, although of greater seriousness and sometimes fatal, is produced by sudden severe haemorrhage, either from an external wound or from bleeding into the peritoneal cavity.

Consciousness is rapidly lost and there may be severe convulsions, which, like the convulsions of asphyxia, are due to the transient phase of increased excitability through which the nerve-cells of the brain pass after their oxygen supply has begun to fail and before this failure leads to paralysis of their functions with coma and paralysis.

Differential diagnosis

In ordinary circumstances no diagnostic difficulty arises, but when consciousness is suddenly lost, or convulsive movements are seen, the possibility of the seizure being epileptic in nature may arise. An error of diagnosis in either direction may lead to serious consequences to the patient. In these circumstances a careful inquiry into the conditions under which the attack has occurred, the presence or absence of exciting factors known to induce syncopal attacks, and the past history of the patient, will probably serve to establish an accurate diagnosis. Of course, incontinence of urine or tongue biting indicate the epileptic character of any attack in which they occur, but it is nevertheless highly important to remember that in the deep unconsciousness of a simple faint, some convulsive movements may occur.

Related conditions

Unfortunately, the term ‘vasovagal attack’ has been applied by Gowers to a form of attack in which there are no clear indications of either vagal or of vasomotor disorder. The descriptions of this are derived from the patients, and the attacks themselves do not seem to have been adequately studied. The symptoms are abdominal and precordial discomfort, sometimes actual precordial pain and a sense of impending death. The extremities become cold and the face pale. Consciousness is not lost, although cerebration may be slowed down. The attack develops gradually and wanes gradually, and may last in all for half an hour. The pulse is said to be small, but is not known to be slowed or irregular.

Nothing is known of the blood-pressure in the attack. The patients are mostly young women.

The term has come to be somewhat loosely used and is applied to almost any ill-observed or obscure form of 'attack'. Its use should be restricted to the syncopal attack just described, which clearly has vagal and vasomotor components. What may be the nature of the attacks Gowers described is not known, and it is not even certain that one condition only was in question.

Treatment In subjects liable to recurrent fainting, the particular exciting factor must be sought and eliminated. In children, this is sometimes undue activity in the fasting state, as study or morning chapel before breakfast. In debilitated subjects, or the subjects of chronic infection or of cardiac disease, the underlying condition calls for treatment and management. Having fainted, the subject should be put in the supine position before the familiar household remedies are applied: namely, smelling salts, the application of water, administration of brandy, and so forth.

2.–HYPERTENSIVE ENCEPHALOPATHY

Definition This term is intended to comprehend that series of more or less transient disorders of cerebral function which occur from time to time in the subjects of what is called 'essential hypertension' or 'hyperpiesia'. Almost any cerebral function may suffer such a temporary disturbance, and it is the transience rather than the form that characterizes the symptoms of the condition. An attack is preceded by a rise of blood-pressure.

Aetiology Hypertensive encephalopathy may be appropriately considered between general cerebral anaemia and the local anaemia of arterial occlusion, because its symptoms have been attributed to a local anaemia caused by angiospasm and they are certainly associated with the degenerative arterial changes that we find in the case of cerebral thrombosis.

The transience of the symptoms in an hypertensive attack has presented considerable difficulty to those who have sought to explain it. It cannot easily be attributed to retained toxins since in typical cases there is no indication of renal inadequacy. On the other hand, symptoms so short-lived cannot, it is thought, be due to structural lesions such as softening following arterial occlusion. A complete hemiplegia which comes and goes within an hour can only be due to a disorder of function without structural damage or destruction of nerve cells or fibres. It is for this reason that the hypothesis of arterial spasm has gained favour, not because there is any unequivocal evidence that such spasm does, or can, occur, but in reality to meet an intellectual difficulty. It is important that we should consider angiospasm of cerebral arteries, at any rate as a possibility. In favour of spasm it is said that the essential arterial lesion in the hypertensive encephalopathy is a diffuse hyperplastic sclerosis which does not render muscular spasm in the affected artery impossible. On the other hand, the final end of most cases of hypertensive encephalopathy is death from cerebral haemorrhage or thrombosis in the presence of cerebral atheroma, a state of affairs which renders the idea of arterial spasm peculiarly unconvincing.

Whatever be the facts as to angiospasm, this may be said, that the symptoms of an hypertensive attack are compatible with, and most easily explained by, a temporary local anaemia of the brain. This might well be caused by a temporary stagnation of blood in a narrowed vessel, leading to a state of anoxaemia of the relevant region of the brain. There is some evidence that, in the subjects of cerebral arterial degeneration and high blood-pressure, a steady level of systolic pressure is not so well maintained as in the healthy subject, and fluctuations more easily occur. In the presence of narrowed and tortuous vessels such fluctuations might well lead to transient disturbances of blood-supply.

Symptoms

Two forms of hypertensive attack have been described, one with and one without signs of cerebral oedema.

The hypertensive attack with cerebral oedema. McAlpine describes this as occurring in childhood, adolescence or early adult life. The patient may have essential hypertension with no evidence of renal lesion, he may be a child with acute nephritis or the subject of a chronic nephritis. A rise of blood-pressure above its customary level in the subject is said to herald the attack, of which the symptoms are severe headache, vomiting and drowsiness—increasing sometimes to stupor or semi-coma. Occasionally epileptiform convulsions may appear, or focal paralytic signs (hemiplegia, monoplegia, hemianopia, etc.). There is hypertensive retinitis, to which may be quickly added marked oedema of the disc, with haemorrhages and exudate. The pressure of the cerebrospinal fluid may exceed 250 mm. of water. The blood urea is within normal limits. In essential hypertension there is some albumin in the urine, and in nephritis the urine is characteristic of the renal lesion.

The subject may make a good recovery in a few days or a week or two, but remains liable to further attacks of the same kind, and to severe or fatal vascular lesions of the brain.

The hypertensive attack without cerebral oedema (‘*cerebral vascular crisis*’). The patient in this case is commonly middle-aged or elderly and the subject of high blood-pressure. The symptoms here are mainly of some focal disorder of cerebral function, a Jacksonian or a generalized epileptiform attack, a transient aphasia, hemianopia, monoplegia or hemiplegia. There is a high blood-pressure, but no papilloedema. In an uncomplicated case, the blood urea is within normal limits, but the urine may contain some albumin. These symptoms recur at irregular and sometimes frequent intervals, and as in the type of attack previously described, they lead up ultimately to a gross vascular cerebral lesion in many cases.

Differential diagnosis

From cerebral atheroma

It is difficult to draw a line between this symptom-complex and the clinically identical one that may be associated with progressive cerebral atheroma. In the latter, the last years of the patient's life may be punctuated by episodes like those just enumerated, and death may ensue from haemorrhage or thrombosis. It is probable that the distinction between the hypertensive encephalopathy and cerebral atheroma is sometimes a conventional and artificial one, and the notion of a special hypertensive encephalopathy is designed rather to meet the difficulty of explaining temporary paralyses than to express any known or observed process of angiospasm.

From uraemia

The differential diagnosis between true uraemia and hypertensive encephalopathy depends upon an examination of the urine and an estimation of the blood urea. In an uncomplicated hypertensive attack the blood urea is within normal limits, albumin is found in the urine and casts and red cells may also be present.

Treatment

The hypertensive attack with cerebral oedema calls for prompt treatment: venesection to reduce the systemic blood-pressure, and the administration of hypertonic saline to reduce intracranial pressure and cerebral oedema. The latter may be given intravenously (70 c.c. of 15 per cent sodium chloride in distilled water or the same quantity of 50 per cent glucose solution). In less urgent circumstances a rectal injection of ½ ounce of magnesium sulphate in 6 ounces of water will suffice. This can be repeated daily. The general treatment of the underlying hyperpiesia is dealt with in the appropriate section. The treatment of the so-called cerebral vascular crises will be discussed under the heading Cerebral Atheroma (see p. 652).

3.–CEREBRAL ANEURYSMS

Definition

The aneurysms considered here are true saccular aneurysms upon the arteries outside the brain, particularly those which enter into the circle of Willis, and not the so-called miliary aneurysms found upon the perforating branches of the middle cerebral artery in the substance of the brain. They are also discussed in the article on ANEURYSM in Vol. I, p. 531.

Aetiology

The subject of aneurysm is usually a young person or an adult of or below middle age. It is said that females are more commonly affected than males. The cerebral arteries are peculiar in the thinness of their coats and in their relative lack of support by surrounding tissue. To these elements of weakness may be added, in the subjects of aneurysm, congenital defects in the arterial wall at points of bifurcation. It has been noted too that when an aneurysm is found upon one of two paired arteries, the other may be abnormally small or vestigial, and it is suggested that the compensatory enlargement of the former may lead to the development of an aneurysm upon it. Aneurysms occur on the various arteries in the following order of frequency: the middle cerebral, basilar, internal carotid, anterior cerebral and anterior communicating arteries. The points of junction of internal carotid and anterior communicating, posterior and middle cerebral arteries are also common sites. When the aneurysm occurs upon the middle cerebral as it enters the Sylvian fossa, it may become adherent to the brain—with consequences to be discussed. Syphilis and atheroma play no part in the formation of these aneurysms, but occasionally the lodgement of a mycotic embolus may lead to local dilatation.

Morbid anatomy

They are true aneurysms, usually saccular in form and of all sizes up to a centimetre in diameter; an average size is that of a pea. As a rule they are thin-walled and filled with clot. When they rupture the pia over them usually does not tear, so that blood is extravasated over the surface of the brain, and is apt to follow the course of the artery on to the convexity. It spreads backwards from the chiasma over the base, and may pass over the lateral aspect of the pons to the fourth ventricle.

On the other hand, especially when it lies in the Sylvian fossa, the aneurysm, having first become adherent to the brain, may rupture intracerebrally. Or it may bleed into both the brain and the subarachnoid space. In yet other instances, the aneurysm may, by compressing the adjacent brain, lead to a local softening.

Symptoms

A cerebral aneurysm may produce symptoms before rupture by compressing adjacent structures, but commonly its presence is first revealed either by slight leakage of blood or by free extravasation into the subarachnoid space.

Before rupture

Before rupture an aneurysm rarely leads to raised intracranial tension; its symptoms are local paralyses together with such subjective manifestations as headache and, sometimes, a rhythmical tinnitus which, upon auscultation, may be heard as a bruit. The paralytic signs include cranial nerve palsies (third, fourth and sixth nerves), sometimes optic atrophy and proptosis.

After rupture

Upon rupture, when the leakage is slight there is headache, some rigidity of the neck, smallness and sluggishness of the pupils and vomiting; then, when haemorrhage becomes free, there follow the characteristic signs of subarachnoid haemorrhage. These are described in the article on APOPLEXY (Vol. I, p. 712), but may be summarized here. There is sudden violent headache—so sudden that the patient may subsequently speak of it as resembling a blow on the back of the head—occasionally epileptiform convulsions, and then rapid loss of consciousness. How deep and how long-lasting this is depends upon the severity of the haemorrhage. In some cases it is but transient, in others it deepens within two or three hours to death. The pulse-rate at the onset may be almost imperceptible, but as the initial shock is passed it regains force but remains slow (48 to 60 per minute) for two or three days in some cases. The temperature rises one or two degrees in an hour or so and remains thus irregularly raised for from five to eight days. During the first forty-eight hours the urine may contain abundance of albumin (massive albuminuria) and a little sugar. The former finding sometimes leads to a diagnosis of uraemia. If consciousness is regained severe headache continues for some days, and the patient may remain in a semi-conscious and irritable state for this period.

The pupils may be small, sluggish and unequal; there may be squint, and ophthalmoscopic examination often reveals slight oedema of the disc, retinal and subhyaloid haemorrhages. In uncomplicated subarachnoid haemorrhage there is no paralysis of the limbs, but there is often a bilateral extensor plantar response.

Prognosis

The later course varies: there may be a recurrence of bleeding at some time during the first fortnight with a fatal issue, but if this time be survived a complete recovery may be looked for. In a few cases some residual symptoms persist indefinitely—e.g. slight mental deterioration, headaches and vague physical debility.

Treatment of apoplexy is fully discussed in the article under that title (see Vol. I, p. 726).

4.–CEREBRAL ATHEROMA

It is not necessary to discuss here the aetiology of atheroma, nor to describe in any detail its morbid anatomy. These subjects are fully considered under the title ARTERIAL DISEASE AND DEGENERATION (p. 39). The thin-walled cerebral arteries are particularly liable to be distorted by the patchy distribution of the intimal degenerative process which is characteristic of atheroma, the lumen of the arteries is irregularly narrowed and the vessels rendered tortuous. In addition, there may be thrombus formation upon the surface of atheromatous plaques, and this, with the narrowing, favours the occurrence of occlusion. In these circumstances the blood-supply of the brain may be disturbed either by arterial occlusion and ensuing thrombosis, or by rupture and haemorrhage, or it may be chronically affected by a steady reduction of the blood-supply through all the arteries and arterioles. This reduction leads in time to a degeneration of the parenchyma of the brain and particularly to a loss of nerve cells.

Symptoms

It is clear that there will be many and diverse pictures of cerebral atheroma. At one extreme we have massive thrombosis or haemorrhage leading to disabling or fatal apoplexy, and at the other a slow process of narrowing of tiny vessels here and there in the cerebral hemispheres, leading to slowly progressive disabilities which will vary in their nature according to the site and extent of the arterial lesion.

Of these clinical types, the apoplexies have already been described (see Vol. I, p. 712). These follow massive occlusion or arterial rupture and haemorrhage. Their forms vary according to the vessel affected and the region of the brain involved.

There remain for description (1) the common chronic type, (2) arteriosclerotic Parkinsonism and (3) pseudo-bulbar palsy.

(1)—The Common Chronic Type

The pictures of chronic cerebral atheroma have as their basis tiny arterial occlusions and minute thrombotic lesions together with nerve-cell degeneration.

One of the commonest sequences of events is that which opens with a very gradual lessening of mental capacity and emotional stability and an accompanying slow restriction of physical power. This is punctuated from time to time as the disease advances by clinical episodes of thrombotic origin, such as transient aphasia, monoplegia, hemiparesis, hemianopia or an epileptiform convulsion. After each such episode recovery is imperfect and the progress of the condition is steadily downhill until it ends after a period of years in a broncho-pneumonia or in a massive vascular lesion.

In subjects who have recurring apoplectiform seizures of this order it is not uncommon for the final 'stroke' to be a haemorrhage, and it has been suggested that every massive haemorrhage is preceded by a local softening. This leaves the arterial branches in the affected area still further unsupported and causes local weakening of their walls, thus predisposing to a terminal haemorrhage. That a slowly spreading softening may follow arterial occlusion is certain. The hemiplegia following such an occlusion may gradually increase in severity, and be accompanied by a growing mental feebleness and lethargy of the patient until, some weeks after onset, death may ensue. In haemorrhage, on the other hand, the death-rate is always highest within the first four days.

Differential diagnosis

Amongst primary diseases of the brain, tumour occupies one of the first places, and in middle-aged and elderly subjects the differentiation of tumour from cerebral atheroma may be difficult. The clinical picture of a tumour when it occurs in the subject of early atheroma is not so clear as in a younger individual, and localizing signs are apt to be later in appearance. Papilloedema when present may for a time be mistaken for a hypertensive retinitis, or it may be lacking until the late stages of the illness. Again, headache and dizziness are symptoms common to both conditions. In these circumstances, the presence of hyperpiesia, and of retinal changes apart from obvious oedema of the optic disc, favour atheroma rather than tumour. Moreover, the course of atheroma is more likely than that of tumour to be marked by sudden apoplectiform episodes with temporary residual paralyses. In tumour, the course is more steady, and such focal signs as appear are more constant and less changeable, and increase more steadily than the more kaleidoscopic signs of atheroma. Sooner or later, definite papilloedema, morning headache, increasing mental apathy and the signs of a progressive local lesion make the presence of tumour clearer. But in such circumstances, careful examination of the urine, and possibly estimation of the blood urea, are essential to avoid making a diagnosis of tumour in a case of impending uraemia or one of cerebral atheroma.

From various epileptiform seizures

The occurrence of generalized epileptiform fits in a middle-aged or elderly subject who has no other symptoms also calls for similar measures. It is not uncommon for intracranial tumour to herald its development in this way, weeks or months elapsing before objective physical signs of tumour appear. Similarly, cerebral atheroma includes fits amongst its symptoms. The epileptiform seizures of early general paralysis of the insane may be recognized by the presence of other clinical and serological signs of this disease.

From apoplexy

The differential diagnosis of apoplectic coma from other forms of coma is discussed under the heading APOPLEXY (Vol. I, p. 724).

(2)—Arteriosclerotic Parkinsonism; Arteriosclerotic Muscular Rigidity

Symptoms

Under these titles we recognize a slowly progressive clinical state which bears many points of resemblance to Parkinson's disease or paralysis agitans. It differs from this, however, both in some of its features and also in its course. A slowly progressive rigidity of 'waxy' or 'lead pipe' variety invades the neck, trunk and limb musculature. At first it becomes evident in the patient's gait, which tends to be short-stepped and shuffling. All the natural spring goes out of his movements, which become slow and laboured. The arms cease to swing as he walks. The face, too, gradually loses its free play of expression and assumes a set look of a rather sad and sometimes surprised character, the latter being imparted by a retraction of the eyelids. These symptoms, at first slight and scarcely noticeable, gradually increase and may ultimately become gravely disabling.

Mental symptoms

Associated with them are signs of mental deterioration; the patient's initiative, power of decision, association of ideas, memory and judgement lose their fine edge and become blunted. Emotional instability, irritability and petulance may show themselves. He lacks insight into his state and may querulously insist on leading a life for which he is no longer fit—to the possible detriment of his affairs and of his health.

Signs of cerebral lesions

While this state of affairs may develop insidiously, it may on the other hand follow a mild and transient 'stroke'. In the latter case, its course is likely to be punctuated by still other apoplectiform seizures, after each one of which the patient is weaker and mentally feebler. Signs of focal cerebral lesions may be added to the background thus sketched: defects of articulation and of deglutition, with spasmodic weeping or laughter indicative of multiple bilateral thrombotic lesions in the region of the internal capsules and basal ganglia. Cortical lesions may be expressed by aphasic symptoms, apraxia, forced grasping (grasping movements and tonic grasping). The patient may become incontinent of urine and faeces.

General condition

General examination often reveals high blood-pressure, hypertensive retinitis, albuminuria and myocardial degeneration.

Prognosis

Necessarily, the malady is ultimately fatal. An apoplexy may close the sequence of events, or the patient may become bedridden and demented, incontinent, and with limbs in general flexion-contracture, succumbing finally to broncho-pneumonia.

Differential diagnosis

From paralysis agitans

Although the age of onset is approximately that of true paralysis agitans and the course in both states long drawn out and identical in issue, yet a differential diagnosis can usually be made. Hyperpiesia is rare in paralysis agitans the course of which is not punctuated by symptoms of vascular lesions. In fact, cerebral haemorrhage or thrombosis do not occur in this disease. As Parkinson observed, 'the intellects are uninjured', and the dementia common in cerebral atheroma is not seen, save as a terminal phenomenon. Tremor is more common and more marked in paralysis agitans, although there is a form *sine agitatione.* The onset of paralysis agitans is gradual and unilateral, the rigidity and tremor appearing first in one limb, then in the second limb of the same side before it appears in either of the crossed limbs. Such a one-sided mode of development is not the rule in arteriosclerotic Parkinsonism.

(3)—Pseudo-Bulbar Palsy

This is a result of multiple and bilateral thrombotic lesions. There is usually a history of at least two apoplectiform seizures, neither of which may have been severe or attended by loss of consciousness. After the second seizure, which will have involved the half of the brain opposite to the seat of the first lesion, the picture of pseudo-bulbar palsy is developed. It includes the signs of bilateral hemiplegia. On both sides the loss of movements may be slight only, but there is bilateral muscular hypertonus, a spastic gait in which one leg is generally the more severely affected and drags in walking. The most characteristic symptoms involve the movements of muscles innervated by cranial nerves and the cortico-pontine and cortico-bulbar components of the pyramidal system. There is dysarthria which may be so severe as to render the patient's speech unintelligible, reducing him to the utterance of inarticulate noises. In these circumstances the tongue is seen to be small and spastic, and slow and restricted in its range of voluntary movement. Often it cannot be protruded beyond the line of the lips. Swallowing and mastication are similarly disturbed. The patient's lips stand apart and saliva trickles incessantly from between them. Movements of the face carried out to order are widespread and tend to be excessive and caricatured in form. From time to time, the patient breaks into slow and silent weeping in which the tears trickle down his contorted face. Equally, he may break into spastic laughter—a long-drawn-out and hideous caricature of the normal facial movements of laughter. Guttural noises may accompany this contortion. It is often impossible to foretell whether laughter or tears are to be expected, and there is no constant relation between the movement and the appropriate emotional tone.

Symptoms

Dementia

A variable degree of dementia usually accompanies this state, and the patient may be indifferent to the calls of nature, passing urine and faeces in the bed.

Differential diagnosis

Occasionally it may be necessary to differentiate this condition from the spastic variety of chronic bulbar palsy (motor neurone disease).

From chronic bulbar palsy

Commonly in the latter there are some signs of a lower motor neurone degeneration, wasting or fibrillation of the tongue or of the upper limb muscles; but it may happen that upper motor neurone sclerosis predominates, and when this is the case the tongue may be spastic, articulation, mastication and swallowing impeded as in pseudo-bulbar palsy, and there may even be a trace of spasmodic laughter and weeping. But there is no history of apoplectiform attacks, little or no mental change, and sooner or later some indications of amyotrophy make their appearance.

Treatment

In considering the treatment of cerebral atheroma it is expedient to bear in mind the narrow limitations within which we can hope to influence the course of events. Atheroma is a wearing-out process, and this remains true whatever value may be attached to the various hypotheses as to its causation, and we are necessarily fighting a losing battle in any attempt to treat it. If this be so, there are limits beyond which restrictions in the patient's life and habits can hardly be justified. For example, it is not rare for a patient to seek advice with the early subjective symptoms of cerebral atheroma, headache, dizziness, ready fatigue and so on. Examination reveals a raised blood-pressure, perhaps a little change in the retinal arteries. To what extent, in these circumstances, are we to interfere with his mode of life? Clearly, if he is habitually gross in the matter of eating and drinking, if he works to excess or has habits manifestly unsuited to his age and general condition, some restrictions are necessary. Common sense will indicate what they are to be. But more often than not, the patient's regime is not open to obvious objection, his arterial tree is wearing out in spite of an orderly and reasonable mode of living. In these circumstances a minimal interference is indicated. There can be no usefulness in making him a vegetarian, in cutting off all alcohol, or in rendering him afraid of even the mildest exercise. In such a case, the sphygmomanometer is an instrument to be used wisely for the doctor's information only, and not as a means of intimidating the patient and rendering his remaining years a prey to dismal apprehensions. In other words, if we cannot influence the course of events, we need not render the patient a valetudinarian by what are meaningless therapeutic demonstrations. A plain mixed dietary, regular opening of the bowels, the avoidance of fatigue, and regular hours are simple precautions that probably exhaust the list of useful measures. Of these, perhaps the avoidance of fatigue is the most important. There are reasons for thinking that cerebral thrombosis frequently follows unwonted fatigue, possibly because this causes temporary lowering of the habitual level of the blood-pressure and thus allows of stagnation of blood-flow in narrow and tortuous arteries. Indeed, too rapid or too great falls in the systolic pressure are not to be viewed favourably for this reason.

Drugs

Potassium iodide in moderate doses (5 grains) has the sanction of long usage in atheroma. Sleeplessness may call for assistance, and in general it may be said that the continued use of the bromides is undesirable in the elderly subjects of atheroma. It tends to befuddle them and to become toxic. It is moreover a form of intoxication difficult to clear up rapidly. For such patients, a nightly dose of luminal (phenobarbitone), 1 to 1½ grains, is useful, or the administration twice or thrice daily of a tablet of theominal (phenobarbitone ½ grain and theobromine 5 grains) for as long as may be necessary.

Following minor thrombotic episodes, a few days' rest in bed may be necessary, but prolonged confinement to bed is unwise unless it be imperative. For recurrent generalized epileptic fits (the so-called senile epilepsy) the continuous administration of phenobarbitone in adequate dosage (½ to 1 grain three times a day) is necessary. Sometimes the altered mental and emotional state of the patient calls for continuous supervision, and the social problems that such a situation may create are often very difficult, for such a patient may prove very wearing to his relatives.

Drugs and glandular preparations, which are said to lower blood-pressure and stay the advance of atheroma, flow into the market in an unending stream, heralded by a fanfaronade of literary persuasiveness that few can resist. It would be idle to mention any of them by name, for their life is but ephemeral. Happily most of them are inert, and this enables them to fulfil safely the perennial demand for something new in the way of a placebo.

5.–SYPHILIS OF THE CEREBRAL ARTERIES

There is little that need be said here upon this subject as it has been covered under the heading Apoplexy.

Morbid anatomy

The essential element in the various forms of syphilis of the cerebral arteries is thickening of the intima and obliteration of the lumen—endarteritis obliterans. No less than four types of this process have been described by Jakob, but they cannot be differentiated clinically and thus need not be discussed in detail. The arterial disease of syphilis is invariably accompanied by involvement of the pia-arachnoid and by some encephalitis. These associated lesions tend to increase the severity of the thrombotic changes in the brain and thus hinder natural processes of recovery. The vessels affected are those which are also the seat of cerebral atheroma. Occlusion and thrombosis, not rupture with haemorrhage, are the basis of the clinical disturbance (see Arterial Disease and Degeneration, p. 39).

Symptoms

The occurrence of a thrombosis with its apoplectic onset is commonly preceded by a sequence of premonitory symptoms, of which headache, irritability and perhaps a slight impairment of the highest mental functions are the commonest. The paralyses resulting are identical with those produced by atheromatous occlusion and have been described in the article on Apoplexy.

Diagnosis

There is a presumption that cerebral thrombosis occurring in a young adult is probably syphilitic in origin. It is known, of course, that thrombosis may occur in non-syphilitic subjects in the course of severe infections, and even as a complication of pregnancy and delivery, but the appropriate examination of the blood and cerebrospinal fluid will suffice to establish the presence of syphilis. Unless it is accompanied by meningeal lesions, vascular syphilis may produce no pathognomonic changes in the cerebrospinal fluid. The Wassermann reaction is frequently negative (although positive in the blood). There is only a slight increase in the number of lymphocytes present (very rarely as many as 50 per c.mm.), but the globulin (Nonne-Apelt) test is usually positive. The Lange gold curve usually is of luetic form if it be changed, but commonly it is normal: i.e. in the absence of meningitis.

Examination of cerebro-spinal fluid

Treatment

The treatment of neurosyphilis is dealt with in the article under that title.

6.–CEREBRAL VASCULAR DISORDERS IN BLOOD DISEASES

In anaemia

In severe pernicious or secondary anaemia, the patient may complain of various subjective symptoms, such as dizziness—particularly on sudden changes of position—headache, feelings of faintness and tinnitus. There may also be marked sleeplessness, and in severe cases mental disorders: namely, confusion and disorientation with hallucinations. In the final stage of pernicious anaemia delirium and convulsions may occur. The writer has seen two cases of pernicious anaemia with subacute combined degeneration of the cord in which mental disorder was so striking a symptom that a form of insanity had been diagnosed before the underlying physical lesions had been recognized.

In acute leukaemia

In acute leukaemia, haemorrhage into the substance of the cerebral hemisphere or pons may be a terminal complication.

In erythraemia

In erythraemia (polycythaemia vera) subjective cerebral symptoms may be prominent. They include dizziness, headache, unilateral paraesthesiae ('pins and needles' in the extremities), and transient blurring of vision. Objectively, we may observe retinal haemorrhages, oedema of the optic disc, hemianopia, transient aphasia or hemiparesis, and sometimes ocular palsies. Cerebral thrombosis may occur with the usual consequences.

Diagnosis

In all these maladies the cerebral symptoms are but complications occurring in the course of readily recognizable diseases, and problems of neurological diagnosis do not therefore arise.

Treatment

In all these cases, the treatment is that of the underlying disease.

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BRANCHIAL CLEFT AND CYST

See NECK: TUMOURS AND OTHER MORBID CONDITIONS

BREAKBONE FEVER

See DENGUE

BREAST DISEASES

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1.–ANATOMY OF THE BREAST

191.] The breast is a simple glandular structure situated in the subcutaneous tissues on the front of the chest. It lies in the superficial fascia, over the deep fascia covering the muscles of the chest wall, the inner part being over the pectoralis major and minor muscles, and the lateral part being over the serratus magnus muscle.

Glandular tissue

The glandular tissue of the breast varies very widely both in amount and in functional value. Many large pendulous breasts are composed almost entirely of fat, whereas the small breast frequently contains a relatively large amount of glandular tissue and may be of correspondingly greater functional value. Normally the glandular tissue extends from the second rib above to the sixth rib below, and spreads inwards almost to the edge of the sternum and outwards to the mid-axillary line. A prolongation of glandular tissue is commonly found in the lower part of the axilla; this is occasionally the site of a primary carcinoma.

The nipple

Surmounting the glandular tissue is the nipple to which the breast substance is firmly attached and on which the openings of fifteen to twenty ducts can be demonstrated. These ducts drain an equal number of lobes, into which the breast can be divided.

The areola

Ligamenta suspensoria

Surrounding the nipple is an area of pigmented skin, the areola. It should be borne in mind that occasionally melanotic carcinomas originate in this situation. Running between the skin and breast substance are a number of very fine fibrous bands known as the ligamenta suspensoria of Astley Cooper.

Blood-supply

The chief blood-supply of the breast is from the long thoracic artery, a branch of the axillary artery. This vessel constantly runs along the lower border of the pectoralis minor muscle. In addition, small branches given off from the internal mammary artery inside the chest perforate the anterior ends of the intercostal spaces and supply the inner part of the breast.

Lymphatic drainage

To axillary glands

The major part of the lymph from the upper and outer parts of the breast is carried to the axillary group of lymphatic glands. These glands may be subdivided into groups. The anterior group is found on the anterior wall of the axilla along the lower border of the pectoralis minor muscle in contact with the long thoracic artery. The second group is found at the back of the axilla in contact with the subscapular artery. The principal glands, known as the vascular group, lie in contact with the axillary vein. The upper part of this group is sometimes described as the subclavicular group. In addition a few small central glands can be demonstrated on the floor of the axilla.

To other glands

From the inner part of the breast lymph drains to the lymphatic glands along the internal mammary artery. Any connexion between the lymphatic vessels of both breasts across the front of the sternum is very unusual.

Occasionally a small lymphatic vessel can be traced upwards from the upper part of the breast passing over the clavicle direct to the supraclavicular glands.

From the lower part of the breast lymphatic vessels pass downwards and inwards over the anterior sheath of the rectus muscle to the umbilicus, where they penetrate the abdominal wall. From this point lymph is carried along the ligamentum teres to the liver.

Knowledge of the lymphatic drainage of the breast is of the very greatest importance for a proper understanding of carcinoma of the breast.

2.–CONGENITAL LESIONS AND THEIR TREATMENT

192.] Surgical text-books describe many congenital abnormalities of the breast, but in practice few are important.

Absence of breasts

The very rare absence of one or both breasts is often associated with a partial or complete absence of the pectoral muscles.

Supernumerary breasts

The presence of supernumerary breasts, especially in the axilla, is probably much commoner than complete absence of the breast. As many as five breasts have been found between the front of the axilla and the umbilicus—i.e. along the line of the primitive mammary ridge.

Multiple nipples

Accessory nipples are frequent on this line—most commonly just below the breast or just behind the anterior fold of the axilla. It is rare to find more than two.

Congenital hypertrophy

Great over-development of both breasts is occasionally observed and in some cases one breast has been very greatly enlarged compared with the other. Thin under-developed women may sometimes have enormous breasts; this has not yet been definitely explained, but possibly it may be the result of an endocrine derangement. Occasionally surgical removal of part or the whole of the hypertrophied breast has been necessary.

Depressed nipples

Depressed nipples are probably the most common and clearly the most important of all congenital lesions of the breast. A fair number of young primiparae show this condition. The nipple is so depressed that it is very difficult if indeed not impossible for a baby to suck satisfactorily, and as a result the child suffers from vain attempts to gain nourishment, and the mother has considerable pain from excessive engorgement of the breast. Efforts on the part of both mother and child to make suckling possible tend to scratch the nipples, which become infected. Abscesses in an engorged breast may be due to the condition of depressed nipples. It is therefore important that careful attention should be paid to the breasts of all pregnant women during antenatal examination. In the event of the nipples being considered too depressed to function, much can be done by gentle massage of the surface of the breasts towards the nipples. This should be done daily and with each treatment an attempt should be made to draw out the nipples, the strictest cleanliness being observed. It is convenient to use some simple cold cream or some oily substance such as olive oil when doing this to prevent the formation of sores on the nipple. Many experienced midwives advise, as an alternative method, bathing the nipples with spiri after a gentle attempt to make them more prominent, and this procedure seems advisable as experience has proved its great value.

If, in spite of this treatment, the nipples remain depressed, the breast pump should be used to relieve the engorged breast, and the question of feeding the child artificially should be considered.

Gynaecomastia Gynaecomastia, or enlargement of the male breast, may be unilateral or bilateral, and the breast may resemble the non-functioning breast of a woman. It may occur in normal men, but most frequently occurs in men who show some evidence of incomplete genital development.

3.–TRAUMATIC LESIONS AND THEIR TREATMENT

193.] Probably no part of a woman's body is more liable to trauma than the breast, and the high incidence of malignant disease in the female breast may be associated with this fact. It is important that women with large breasts should keep them carefully supported by properly fitting brassières; serious injuries are then much less frequent. The practitioner should see that women realize the importance of wearing suitable breast supports (see p. 676).

Severe breast injuries must be treated in the same way as severe injuries in other parts of the body. The importance of excising the wound in the case of a cut, of local and general rest and of good symptomatic treatment for the relief of pain must be emphasized.

Haematomas Very large haematomas sometimes appear in the breast soon after an injury. The majority gradually subside after treatment on the above lines, but it may be necessary in extreme cases to relieve tension by making a small incision into the haematoma; but owing to the risk of infection this should not be carried out without the most serious consideration.

4.–INFLAMMATIONS AND THEIR TREATMENT

194.] Inflammations of the breast are divided into acute and chronic types.

(1)—Acute Mastitis and Breast Abscess

(*a*) *Acute Mastitis of Infancy*

Newly-born infants occasionally have painful swellings of the breast, which may be unilateral or bilateral. Though occurring in both sexes they are probably commoner in females. They appear very much more frequently among the poorer members of the community. Even in these enlightened days there is a belief that in female children the so-called nipple strings should be broken down; this dates from time immemorial, and occasionally the practitioner sees cases in which some interfering woman has massaged the child's breasts with her dirty fingers, and thus caused acute mastitis. Treatment consists in the application of heat locally, and if suppuration occurs, as it does in a very few cases, a small incision should be made over the abscess. Most cases clear up without any further operative treatment. *Treatment*

(*b*) *Acute Mastitis of Puberty*

At puberty the female breast begins to enlarge, and in view of the rapid physiological change then taking place it is not surprising that acute inflammation sometimes occurs, especially if the patient has sustained any mild degree of trauma and particularly when it has been repeated. These patients must be treated on the lines laid down for acute inflammation in any part of the body. In severe cases general rest in bed for a few days is indicated. Local application of heat together with a proper support will help considerably, the majority of cases subsiding rapidly. In a few, however, suppuration occurs, and this necessitates incision. *Treatment*

(*c*) *Acute Mastitis of Lactation*

By far the commonest inflammatory lesion of the breast is the acute mastitis connected with lactation. As in a number of other conditions, this is most frequent amongst the poor, especially those with some degree of depression of the nipples. The unpleasant condition known as milk engorgement of the breasts is an almost invariable precursor of this mastitis.

Clinical picture At the onset there are considerable discomfort, pain and swelling of the breast. On examination there is an abnormal prominence of a section of, or the whole of the breast, the affected region is hot and tender, and there is possibly some oedema of the skin. Later, suppuration occurs in more than half the cases, and the patient then presents the clinical picture of a breast abscess.

Treatment In treatment the following points must be very strongly emphasized. The mother must stop feeding her baby, and must be given routine aperients to keep the bowels acting freely. Treatment in bed is absolutely essential, otherwise a bad case may not clear up. Locally, heat in the form of fomentations is recommended, but other local applications are not worth consideration. Fluctuation should be carefully looked for daily, and at first a small central area of fluctuation, together with marked surrounding induration, will be recognized.

Early incision into breast abscesses should be strongly discouraged, and only when fluctuation is very obvious, and surrounding induration minimal, should an incision be made. Gas and oxygen is probably the safest anaesthetic for such purposes. Two counter incisions should always be made into a large breast abscess, as far apart as they can reasonably be placed. A piece of rubber-glove drain is inserted for twenty-four hours, after which it is removed, and the abscess is then allowed to discharge freely. The majority of cases clear up with this treatment.

Bacteriological findings

Cultures of the pus from these cases show that *Staphylococcus pyogenes aureus* is usually present and sometimes a haemolytic streptococcus. As a rule the prognosis is less favourable in streptococcal than in staphylococcal abscesses.

Chronic pyogenic mastitis

Occasionally cases are resistant and a hard indurated lumpy breast with one or more discharging sinuses remains, the condition having become a chronic pyogenic mastitis. The patient's general resistance should be built up in such cases. Very chronic cases sometimes respond to local applications of ultra-violet or infra-red light, and very good results have been claimed for short-wave diathermy treatment, but as this form of treatment is still in the early stages of investigation it should not be recommended at present. Amputation of the affected organ may sometimes be the only method of cure.

(2)—Chronic Mastitis

Chronic mastitis is a rare condition. Chronic interstitial mastitis, no longer regarded as inflammatory, is considered on page 675. Reference has already been made to chronic pyogenic mastitis following the acute form. Specific forms of chronic mastitis are not very common in England.

Syphilis

Syphilis of the breast is sometimes recognized clinically. Extra-genital primary sores have occasionally been seen on the nipples. In the secondary stage of this disease the generalized rash frequently covers the breasts, and very occasionally gummata have been diagnosed. The usual history is complaint of a hard mammary swelling, which is quite painless and may easily be regarded as a carcinoma. The Wassermann reaction is almost invariably positive, and cases respond rapidly to the antisyphilitic remedies.

Tuberculosis

Tuberculosis of the breast is not common in England, but it is said to be fairly common in some parts of the world. Infection is probably haemic in origin, but occasionally spreads directly from the chest. It produces a hard induration of the breast substance, and sinuses discharging tubercle bacilli may be present. If the condition is moderately localized, excision of the breast should be considered. Otherwise general antituberculosis treatment combined with local artificial sunlight is indicated.

Actinomycosis

Actinomycosis has been recorded in very rare instances (see Vol. I, p. 173). The organism may enter by an abrasion or cut, or spread from the chest wall. The diagnosis is usually made by recognition of the *Actinomyces bovis* in the pus coming from sinuses. The typical sulphur granules can sometimes be seen. Treatment is on general lines and especially by means of large doses of iodides—i.e. up to 90 grains of potassium iodide three times a day.

5.–TUMOURS AND THEIR TREATMENT

195.] Tumours of the breast, as of other organs, are classified into two groups, benign and malignant.

(1)—Benign Tumours

(*a*) *Fibroadenoma*

Hard fibroadenoma

Two forms are described—the hard and the soft. The commoner condition is the hard fibroadenoma which occurs principally in women between the ages of fifteen and twenty-five years. The patient complains of a small firm swelling which slips about freely under the examining finger, and is seldom more than half an inch in diameter. The age of the patient and the extreme mobility of the lump make the diagnosis obvious. As with all tumours of the breast surgical excision is the proper treatment.

Morbid anatomy

Examination of the tumour after removal shows that it is of a very firm consistency and is well encapsulated. On section it never presents the hard gritty appearance of carcinoma of the breast. Microscopically it is a pericanalicular and intracanalicular fibroadenoma. Very little glandular tissue is seen in the section.

Treatment

The tumour can usually be removed by means of a radiating incision running from the nipple over the swelling. An alternative method, particularly when the tumour is in the lower part of the breast, is to make a submammary incision, and then remove the tumour from the back of the breast. In practice this method is very easy, and has the advantage of not leaving a very obvious scar.

Soft fibroadenoma

The soft fibroadenoma is very much rarer. It occurs in rather older women between the ages of twenty-five and thirty-five years. The tumour is usually larger than a hard fibroadenoma and frequently reaches the size of a walnut. It is usually encapsulated, and can easily be excised. Microscopically it contains considerably more glandular tissue than does the hard tumour. It may, though very rarely, become sarcomatous.

(*b*) *Duct Papilloma*

This arises in one of the ducts of the breast, and is not actually connected with the glandular breast substance. It is a rare tumour, and even in large hospitals is very infrequent. The patient gives a history of a blood-stained discharge from the nipple. On clinical examination no swelling can be felt in the breast. The condition occurs most commonly in middle-aged women, and as it is extremely difficult to differentiate between early cases of duct carcinoma and duct papilloma, the slightest suspicion indicates removal of the breast. If there is a palpable lump and the glands in the axilla are enlarged the condition had better be regarded as malignant and the full radical operation should be carried out. In other cases of duct papilloma it is not necessary to clear the

Treatment

axilla. If for any reason such radical treatment is contra-indicated, the question of some modified surgical procedure is worth consideration. By stroking different segments of the breast successively it may be possible to show that the blood issues from one particular segment of the breast, and in such a case that segment only may be excised. This has been done quite frequently, and patients have had no further trouble.

The tissues show the presence of one or more small characteristic papillomas in some of the ducts. They occasionally are sufficiently large to obstruct a duct, and so lead to the formation of cystic dilatation deeper in the breast substance. This, however, is extremely rare in duct papilloma.

(c) *Other Benign Tumours*

Lipoma The commonest of these is the lipoma, which may be superficial or deep to the breast substance, or in an intraglandular position.

Both pure fibroma, consisting entirely of whorls of fibrous tissue, and pure adenoma are very rare.

(2)—Malignant Tumours

(a) *Carcinoma*

Incidence With the exception of the cervix uteri the breast is the most frequent site of malignant disease in women. It accounts for one-third of the cases and affects both the married and the unmarried. In males carcinoma of the breast is rare, only one per cent of cases occurring in men. The disease usually arises without warning or reason in an apparently normal breast. It is rare before the age of thirty-five, and most commonly commences about the menopause. As is only natural at that age a certain number of cases are associated with chronic mastitis, but we do not agree that there is any important causal relation between the two conditions. Nearly half the cases occur in the upper and outer quadrant of the breast, and a quarter arise beneath the nipple. When carcinoma occurs in other parts of the breast the prognosis is usually less favourable (see also CANCER, Vol. II, p. 737).

Symptoms In its early stage cancer of the breast is entirely painless, and a tumour often reaches considerable proportions before a patient thinks it necessary to seek medical advice. Local pain is far more likely to be due to chronic mastitis or to some neuralgic condition.

Metastases Carcinoma of the breast spreads almost entirely by permeation of the lymphatics. The malignant cells grow along the lymphatic vessels in all directions equally, but they remain within these ducts, and therefore in the plane of the main lymphatic plexus, until they burst through to invade the adjacent tissues.

The malignant cells from a carcinoma of the breast first reach the great lymphatic plexus of the pectoral fascia and then spread in every direction in this layer, so that the primary growth may be regarded as the centre of a circular zone of invasion. From this layer branching columns of cells may extend towards the skin, in which nodules appear.

It seems that so long as the carcinoma cells remain within the lymphatics they give rise to little reaction in the tissues, and it is only when these boundaries are burst that fibrosis occurs. Thus, although the columns may be strangled by tissue reaction, the heads of the columns advance unchecked, still protected within the walls of the lymphatics. They form a growing front of perhaps only a few millimetres in width; but it is this growing front and not the primary tumour which is the real danger zone. Unless it is removed any operation for cancer is futile, and any form of treatment by surgery or by radiation must take into account this essential detail of pathology.

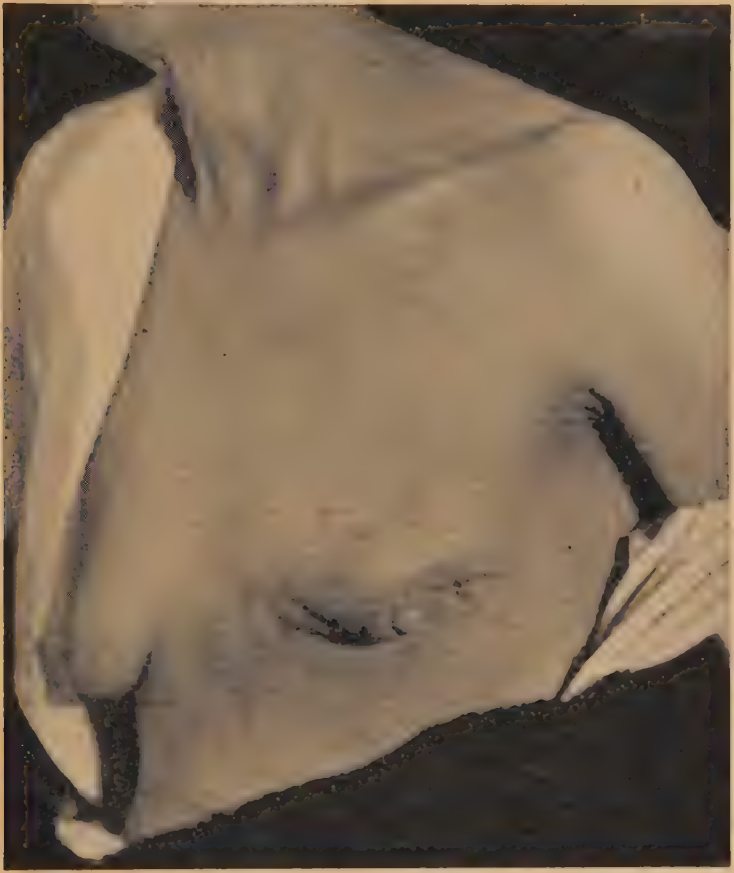

FIG. 106.—Advanced carcinoma of breast

Zone of proliferation

Should the cancer cells reach a serous cavity, such as the pleural or peritoneal cavity, they can spread far more rapidly, invading the whole cavity and implanting themselves upon the serous surface. Thus, if the abdominal cavity is reached, large secondary growths may appear in the pouch of Douglas, without any evident connexion with the primary growth.

Histological varieties

Histologically the growth is almost always spheroidal-celled, and arises in the acini of the gland; its clinical characters depend on the amount of the stroma of fibrous tissue which is thrown out in defence by the individual. Three clinical varieties may be recognized, differing in the relative proportions of fibrous tissue—the medullary carcinoma, the scirrhous carcinoma and the atrophic scirrhus.

Medullary carcinoma

The medullary carcinoma consists of a mass of spheroidal cells forming a soft bulky tumour with little fibrous tissue. The breast is distended by a soft mass of growth which rapidly involves the skin and fungates. This form occurs chiefly in young women and is greatly stimulated by pregnancy; lymphatic involvement and dissemination are rapid. The soft growth suggests an acute abscess rather than a malignant tumour. The vascularity is indicated by the large veins coursing over the surface.

Scirrhous carcinoma

Scirrhous carcinoma is by far the commonest, the fibrous tissue forming a hard tumour of moderate size. Two types are recognized depending on the arrangement of the cells: in adenocarcinoma the cells retain their general glandular arrangement, whereas in carcinoma simplex there is no such arrangement, the cells occurring in solid masses or in isolated groups amongst the strands of fibrous tissue.

Clinical signs

The typical scirrhus forms a definite tumour integral with the substance of the breast, ill-defined, irregular in outline, stony hard and painless. Dimpling of the skin over the tumour is the earliest sign of attachment and may be demonstrated by raising a fold of skin between the finger and thumb. In the early stage the tumour moves with the breast quite freely over the pectoral fascia, but with lymphatic spread this freedom is lost. It is best demonstrated by fixing the pectoral muscles by abducting the arm, or by active contraction, and then attempting to move the tumour in the direction of the muscle fibres. If the tumour does not move when the muscle is free it indicates fixation to the chest wall and extensive infiltration.

The fibrosis following lymphatic permeation, and later the contraction of the fibrous tissue, produce a series of features which are very characteristic of scirrhous carcinoma. The nipple is retracted as a result of fibrosis around the ducts, and the whole breast is drawn upwards in those cases in which, as is usual, the growth commences in the axillary quadrant.

Glands

High up on the inner wall of the axilla a group of shotty glands may be felt. At first they are mobile but later they become matted together and fixed. At a still later stage, the glands above the clavicle become involved and the growth is then beyond the limits of operative possibilities as by this time thoracic metastases are certainly present.

It is only after a long period, perhaps two years or more, that the growth will involve the skin, which breaks down leaving a bleeding ulcer with a sloughing irregular base and thickened edges.

Metastases

By this time secondary deposits may appear in any part of the body, in the thorax, abdomen, in any portion of the skeleton, more especially in the spine, the skull, the humerus and the femur. These bony metastases are often accompanied by very severe pain, especially those

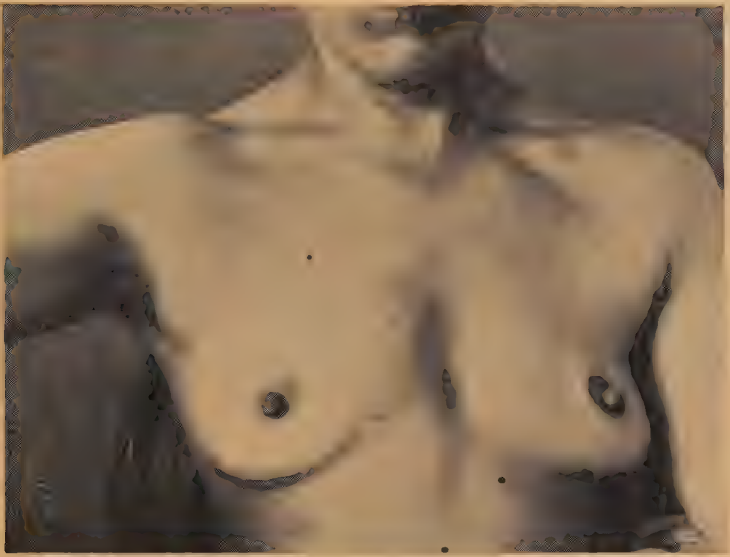

FIG. 107.—Carcinoma involving axillary tail of the right breast. The tumour can be seen in the lower part of the axilla

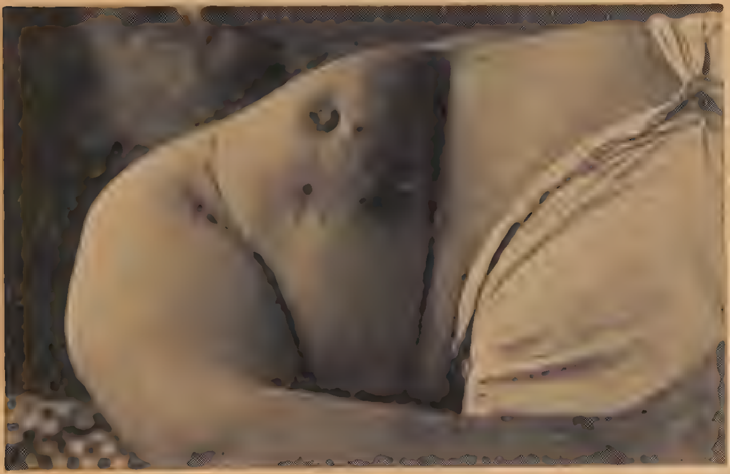

FIG. 108.—Extensive carcinoma of the breast showing nodular deposits in the skin, and typical *peau d'orange*

in the spine from compression of the nerve-roots, and ultimately even the spinal cord may be involved. On the other hand they are sometimes detected on routine X-ray examination before they give rise to symptoms.

Peau d'orange

In advanced cases the obstruction of the lymphatics of the skin occasionally gives rise to the curious condition described as *peau d'orange*. The skin over the breast becomes thick and leathery, the orifices of the sebaceous glands showing as little pits, and the skin being fixed to the underlying carcinoma. This condition may extend and involve the whole of the front of the chest reaching even to the neck, the abdomen and the arm; it is then known as cancer *en cuirasse*, and is due to blockage of the lymphatics by cancer cells. To a similar cause is due the 'brawny' arm seen in the later stage of cancer of the breast; the arm is enormously swollen by solid oedema from a complete lymphatic blockage in the axilla. Its power is entirely lost and the limb becomes a heavy encumbrance.

Cancer en cuirasse

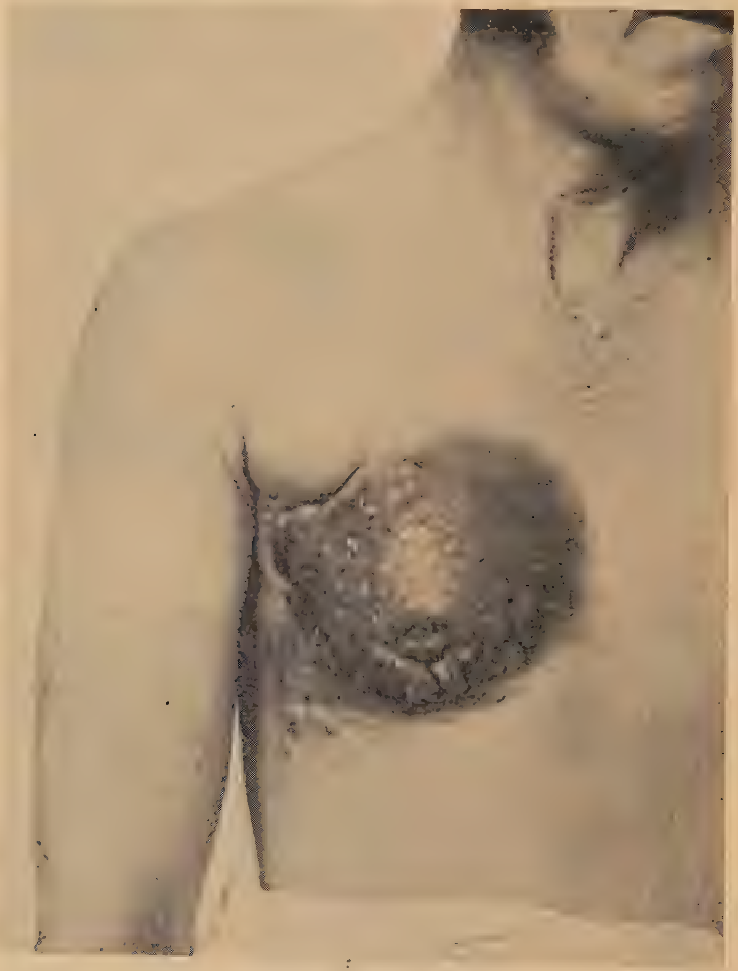

FIG. 109.—Very advanced carcinoma of the breast with skin involvement. Nodular deposits can be made out at some distance from the breast

Atrophic scirrhus

In the atrophic scirrhus, fibrosis is so advanced that the cancer cells may be difficult to see, and the tumour little more than a puckered scar. It occurs in elderly women and the progress is very slow—extending sometimes over several years. The growth may be adherent to the deep fascia. Secondary tumours, however, are not uncommon and in contrast to the original lesion may grow rapidly.

Mastitis carcinomatosa

Young women recently delivered may be attacked by a very rapidly growing carcinoma of the breast, which is usually mistaken for an acute inflammatory lesion; hence the name mastitis carcinomatosa. Fortunately this disease is very rare, but the development of what appears to be an extremely fulminating type of acute inflammation of the breast in young women who have recently been pregnant should always be regarded with suspicion. Treatment is on the lines already laid down for carcinoma of the breast. The prognosis is very grave.

The early diagnosis of carcinoma of the breast is of the most vital importance since the success of early treatment contrasts most forcibly with the hopelessness of treatment in advanced cases.

Differential diagnosis from chronic mastitis

The most common condition with which it is likely to be confused is chronic mastitis, which occurs at a similar age. The most important diagnostic features are that carcinoma always forms a single tumour, that it is neither tender nor painful, that it is usually associated with a secondary fibrosis which deforms the breast, retracting the nipple and drawing the whole breast upwards, and that it tends to become adherent to the skin and to the deep fascia. Chronic mastitis, on the other hand, tends to produce multiple swellings of indefinite outline, tender and painful, never deforming the breast by contraction, and never attached to the skin or to the deep fascia. It often involves both breasts, and tends to be limited to individual lobes, following the sector-shaped outlines of the lobes themselves.

From cyst

A deeply placed cyst may simulate carcinoma very closely and may demand exploration. A similarly situated fibroadenoma may be surrounded by an area of chronic mastitis, and in such cases exploration is equally important.

From gummatous and tuberculous mastitis

Gummatous and tuberculous mastitis are rare, and the history of the case, the occurrence of other lesions, the age of the patient, and the response to treatment should indicate the diagnosis.

From abscess

Occasionally a chronic abscess following pregnancy may be almost indistinguishable from an acute medullary carcinoma, and the diagnosis may only be settled by exploration.

Operative Treatment

From a consideration of the pathology it is obvious that adequate treatment of malignant disease of the breast must include not only the breast but also the whole of its lymphatic area. Any operation must therefore involve amputation of the breast itself with a reasonable margin of skin, and of the pectoral muscles with the pectoral fascia in which lymphatic spread chiefly occurs, and of all the axillary lymph glands.

The removal of the pectoral muscles gives rise to far less disability in the arm than might be imagined, and only by this means can an adequate clearance of the axilla be effected.

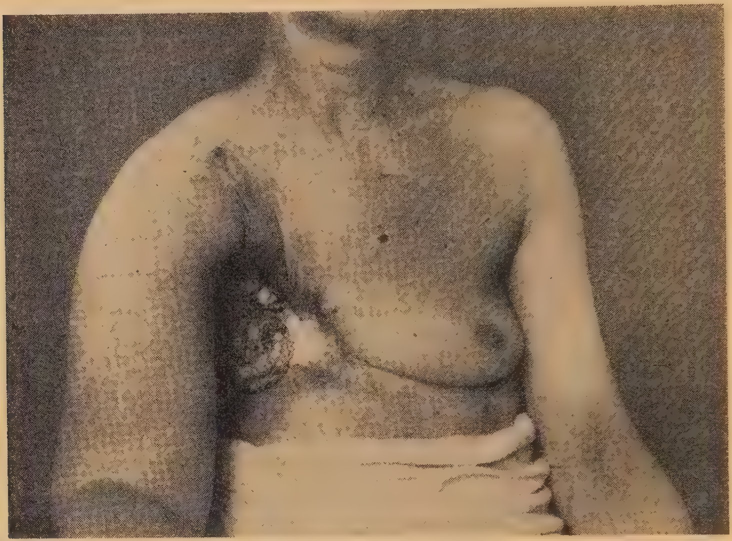

FIG. 110.—Recurrent carcinoma of the chest wall following a radical excision of the breast for carcinoma. Elephantiasis of the right arm is present resulting from lymphatic obstruction in the axilla.

Removal of wide areas of skin, on the other hand, is quite unnecessary, and it should always be possible to close the skin without tension.

Treatment by Irradiation

The treatment of carcinoma of the breast by irradiation has been undertaken as a matter of routine only during the past ten or twelve years. Recurrences and inoperable cases have been so treated for a much longer period, but it is only comparatively recently that irradiation has been used as a primary method. The results, however, have fully established its value and are, in the hands of those thoroughly familiar with the technique, statistically almost identical with those obtained by operation. In early cases, and in young individuals, it will generally be conceded that a complete radical operation is still the safer procedure, but in elderly subjects and in advanced cases we have no doubt at all that the methods of irradiation have a very great superiority. The following description will be confined to the use of radium, but it should be noted that very similar results may be obtained by the use of deep X-ray therapy from a modern high-frequency equipment.

Radium needles

The use of radium needles for treatment of carcinoma of the breast was first developed by Gask and Keynes. Their aim was the uniform irradiation of the whole of the breast and the whole of its lymphatic area. The needles are inserted beneath the breast, beneath the pectoralis muscles, in the axilla, on the costocoracoid membrane, above the clavicle and in the upper third and fourth intercostal spaces. The number of needles inserted is very variable, depending upon the size of the tumour and of the mammary gland. Each needle contains 1 milligram of radium element for each centimetre of active length, and is screened by either 0·8 or 0·6 millimetre of platinum. The needles vary in active length from 1 to 6 centimetres, and the total amount of radium used varies between 60 and 100 milligrams. They are left in place for seven days. If the tumour is very extensive it has sometimes been found of advantage to divide the treatment into stages in order to avoid the excessive reaction which may otherwise occur.

Radon seeds

Radon seeds are containers holding from 0·5 to 2·0 millicuries of radon gas (radium emanation) enclosed in a fine glass capillary and screened in a 0·3 millimetre platinum or gold tube, so that the whole seed is perhaps 0·8 millimetre in diameter and 0·5 centimetre in length. With a suitable apparatus these can be introduced with great rapidity and accuracy in large numbers through a few minute punctures, and their small size renders their removal quite unnecessary. After an extensive experience of their use we are fully convinced of their value, and indeed regard them as in many ways superior to needles. The seeds must be introduced according to a definite plan, in such a manner that the tumour, the breast, and the whole area of lymphatic drainage will receive an equal and uniform irradiation. An attempt is first made to infiltrate the whole of the base of the growing edge of the tumour with parallel rows of seeds, and it will add to the uniformity of distribution if these are inserted in lines on two planes at right angles to one another. In most cases it is convenient to deposit about five seeds in each row, and the greatest care should be taken to ensure the regularity of their distribution. The first layer of seeds should lie in the pectoral fascia and the second in the substance of the tumour, assuming that the latter is of considerable dimensions, but no seeds should be placed in the more superficial portions of the tumour as this will be amply dealt with by cross-fire from the seeds below; it is inadvisable to place any seeds in proximity to the skin. The cannula is now introduced through a puncture in the axilla and passed beneath the pectoral muscles about an inch below the axillary vein, and two parallel rows of seeds are deposited in this direction. Care must be taken not to approach too close to the brachial plexus or a distressing neuritis may result. Other rows of seeds are introduced along the axillary borders of the pectoralis minor and on the surface of the serratus magnus just behind this. Isolated seeds in the intercostal spaces we have given up as being quite unnecessary and indeed useless. No greater mistake can be made than to concentrate upon the tumour; it is far more rational to concentrate on the lymphatic drainage and to use the tumour as an index of the adequacy of the irradiation.

Technique for inserting seeds

The number of seeds introduced and the total dose depend more upon the physical characters of the patient than upon the size or situation of the tumour. The object aimed at is the full and uniform irradiation of the whole of the tissues in which the existence of even a few carcinoma cells may be suspected, and it might be expressed by saying that a Halsted's operation is performed by means of irradiation. Obviously, therefore, a stout patient with a very large breast will require a much larger dose than one with an atrophic breast. In an average case 100 seeds, containing 0·5 millicurie each, will give a sufficient dose, but the number may be increased to 160 or reduced even to 60 according to circumstances.

Reaction of tumour to radon seeds

A few days after the introduction of the seeds it will be noticed that the tumour has become softer, and at the end of a week it may have lost the induration so characteristic of carcinoma. Small tumours may disappear completely in six weeks, and even large fungating masses may have disappeared and the surface have healed in three months. Secondary deposits in glands and recurrences disappear with greater ease than the original tumour, and in the majority of cases all traces of active carcinoma will have disappeared in three months. It must not be imagined that this indicates the cure of the patient, but it certainly represents a very substantial step in that direction. It is an open question if the patient is any more secure after a complete amputation of the breast.

Choice of treatment

In advanced cases and in elderly patients there can be no possible doubt but that irradiation by means of seeds presents immense advantages. Although a general anaesthetic is required the whole procedure takes less than fifteen minutes, and, as it is carried out through a few small punctures, the patient may go home the next day. In a younger patient with an early carcinoma a decision is more difficult, and we are fully aware of the grave responsibility involved in suggesting that under these conditions the breast should not be amputated. On the other hand, it is an equally grave responsibility to advise amputation of the breast if an equally satisfactory result, with no disfigurement, can be obtained by such a simple means as the introduction of radon seeds. It has been our custom in such cases to advise a trial of radium, with the condition that if in three months the result is not completely satisfactory the breast must be removed.

Prevention of skin reaction

One small point in technique should be remembered. Immediately after the insertion of radium the whole of the breast and the surrounding region should be covered with an ointment consisting of equal parts of castor oil and zinc ointment, and this should be removed and replaced daily. If this is done from the outset there will be little or no skin reaction, and the patient will be spared the ulceration which would otherwise occur.

Irradiation from external appliances

The treatment of carcinoma of the breast by irradiation from external appliances is chiefly of use in inoperable cases and especially in those in which ulceration has already occurred. It has the disadvantages that a somewhat cumbersome apparatus must be worn for at least two or three weeks and that a very large quantity of radium must be available;

and that if the skin is unbroken before treatment it will almost certainly ulcerate afterwards, since the radiation it receives of necessity exceeds that which reaches the deeper tissues. In constructing the apparatus the best results will be obtained if the radium is divided into two equal portions, one of which is distributed uniformly over the surface of the plaque and the other around its margin, as in this way the most favourable depth dose is obtained.

A moulded appliance is prepared, accurately fitting the patient's body over the whole of the side under treatment. It should extend over the shoulder and high up into the neck, and it should reach down as far as the epigastrium, and back to the posterior axillary line. It may be made of Columbia wax, but the expanding cellulose material known as nidrose has the advantage of being light and permeable to the air. Upon the outer surface of this cuirass the radium is distributed at as great a distance from the skin as its quantity will allow with 2 centimetres as a minimum. The apparatus should be left in position for about fourteen days, and the quantity of radium should be such that a dose of about 6,000 r units is received at the deep surface of the breast at the centre of the apparatus.

(*b*) *Paget's Disease of the Nipple*

From a pathological point of view this is one of the most interesting conditions met with in the breast. It occurs in women over the age of forty years. The patient develops the clinical picture of a chronic eczema of the nipple and the areola, the nipple gradually disappearing and becoming merged with the whole eczematous area. As the disease progresses it becomes possible in the majority of cases to demonstrate a hard swelling in the breast, just deep to the nipple: this is a carcinoma.

Theories of cause

There are two principal theories of the causation of this condition. According to the first theory the primary change is a carcinoma just beneath the nipple, which causes lymphatic obstruction and consequently dams the lymph back; this now collects in the region of the areola and the result is that the patient develops the chronic eczema already described. The other theory is that the primary condition is the chronic eczema of the nipple and areola, and that this leads to malignant change in the tissues just underneath.

Treatment

Whatever the cause of this condition its association with carcinoma is well recognized, and it must consequently be treated on the same lines as carcinoma of the breast. The obvious surgical procedure would be to perform a complete Halsted's excision of the breast. If this is done fairly early the prognosis is quite good.

(*c*) *Sarcoma*

Sarcoma of the breast is a rare disease and it is probable that many of the cases so described are really medullary carcinomas. A typical sarcoma grows with great rapidity, distending the breast and forming a large globular mass with distended veins, and possibly exhibiting pulsation. The skin becomes thickened and discoloured, and the tumour bursts through, without involvement of the skin. It is possible that some of these tumours have arisen from the connective tissue of a fibroadenoma, the history suggesting that this has remained quiescent for several years. The axillary glands are not usually involved. The only possible treatment is an extensive amputation. When the condition is beyond the hope of local removal, or when it is recurrent, deep X-ray therapy may prove beneficial.

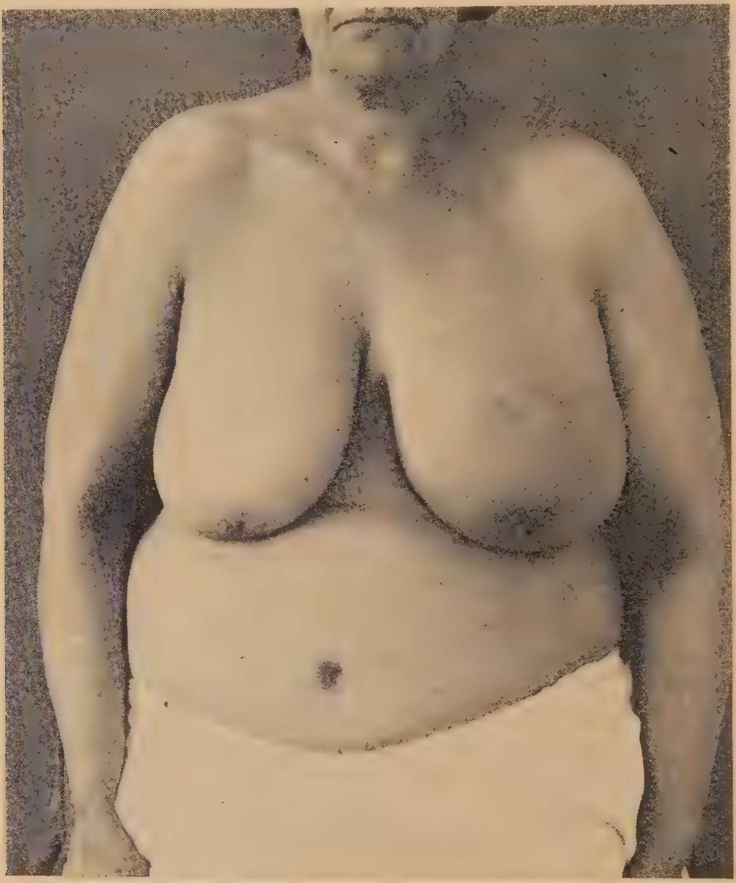

FIG. 111.—Marked enlargement of left breast resulting from a sarcoma of the breast

6.–OTHER BREAST CONDITIONS

(1)—Cysts of the Breast

196.] Cysts of the breast are frequent and their early recognition is extremely important. A number of different types are described and the following deserve attention.

Retention-cysts

Small retention-cysts containing clear fluid and reaching a size of about one inch in diameter are sometimes met with near the surface of the breast. They may be due to some proliferation of the lining epithelium of the ducts. These cysts sometimes are so tense with fluid that they give the impression of being extremely hard, and may be mistaken for malignant tumours. It is sometimes advised that when a clinician is in doubt a needle should be inserted into the cysts in order to establish a diagnosis. We cannot condemn this practice sufficiently vigorously. It must be obvious that if a mistake is made and the lump turns out to be a carcinoma, cancer cells would be spread through healthy breast tissue as the needle is withdrawn. It is vitally important to regard every lump with suspicion, and it is even more important to remove it without any delay.

Galatocele

Galatocele occurs in the lactating breast, as a result of some obstruction to one of the ducts; cystic distension of the duct occurs behind the obstruction. These so-called galatoceles frequently become very large indeed, and in the majority surgical excision through a radiating incision is indicated.

Multiple small cysts

Multiple small cysts are probably more frequently met than any other form of cyst of the breast. They invariably occur in association with chronic interstitial mastitis (see below).

Cysts associated with tumour

Cyst formation is commonly associated with many breast tumours, both benign and malignant.

The cyst-adenomas are the result of cystic degeneration in a pre-existing adenoma of the breast. Diagnosis is not easy but treatment is simple; as a routine such cysts must be removed.

Cystic degeneration is fairly common in both carcinoma and sarcoma of the breast. It is clearly most important to recognize the primary condition at the earliest possible moment.

Other cysts of the breast

Other cysts may occur in the breast. Occasionally lymphatic-space distension-cysts are seen. Even more rarely hydatid cysts have been recorded, but almost invariably in countries where hydatid disease is not uncommon. The patient discovers in the breast small hard lumps, which may become adherent to the skin and break down discharging characteristic daughter cysts and hydatid material. The best treatment is the early removal by dissection of the entire cyst, and if necessary of the whole breast.

(2)—Chronic Interstitial Mastitis

This disease is one of the commonest in the female breast and is consequently of the greatest practical importance.

It occurs particularly in unmarried women, and in married women who have not borne children for many years, and is most common between the ages of thirty-five and forty-five. The patient has a dull aching pain in the breast, and sometimes a lump is noticed; she may also complain of a tender swelling in the axilla. Examination shows a diffuse nodular thickening of part or whole of the breast. In parts a fairly large cystic lump may be present, and the clinician can often palpate a tender, firm, enlarged axillary gland. Except for the aetiological factors described above there is not at present any definitely known cause for this condition. It is considered to be the result of abnormal involution and evolution of the breast substance.

Several observers have noted that this condition tends to occur especially in women who do not wear proper uplifting breast supports and who wear tight clothing which, instead of supporting the breasts, presses them against the lower part of the chest wall. Recently a marked improvement has been seen in some early cases of chronic interstitial mastitis, when the patient has been provided with a properly fitting brassière. In the treatment of this condition the fact must be borne in mind that occasionally cases appear to undergo malignant change. We do not believe that this is at all common. In early stages it is suggested that patients should take potassium iodide by mouth in small doses, but there is grave doubt regarding the efficacy of this treatment. When the condition is well-developed, removal of the breast is probably the wisest procedure. The examination of such breasts shows extensive fibrosis of the breast substance and the formation of many small cysts. Sometimes cysts may become very large, reaching as much as 1½ inches in diameter.

In some instances the disease appears to be localized to a single segment of the breast, and it may then be sufficient to excise just this segment locally through a radiating incision. In many cases an unusually prominent scar can be avoided by making a curved submammary incision, and then removing the cyst or segment of the breast concerned through its posterior surface.

(3)—Neuralgia of the Breast

This condition is fairly common in young women, and particularly in those of neurotic temperament who have a dread of developing cancer. The patient complains of a severe pain in the breast but careful examination fails to reveal any physical signs in the breast. The wearing of proper supports and a suitable sedative medicine usually remove the symptoms. For persistent pain the local application of infra-red rays or diathermy frequently produces a spectacular cure.

7.–NOTES ON SUPPORT OF THE BREAST

197.] The importance of careful attention to the breast supports has been already emphasized. Too often a woman finds it difficult to get a regular size of brassière to fit her, and it is then important to have the necessary supports made by an expert. In growing young women it is not unusual to find that the tight shoulder straps of the brassière have resulted in the adoption of a bad kyphotic posture. This point must always be considered when such a support is being fitted, and it should be possible for the woman to stand properly erect and to breathe easily with her brassière on. With the growth of civilization these supports have become necessary for many women, and when they are not properly constructed and satisfactorily fitted many unpleasant complications may follow.

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BRIGHT'S DISEASE

See NEPHRITIS AND NEPHROSIS

BRILL'S DISEASE

See TYPHUS FEVERS

BROAD LIGAMENT

See FALLOPIAN TUBES DISEASES; OVARY DISEASES; *and* UTERUS, DISEASES AND DISORDERS

BRODIE'S ABSCESS

See BONE DISEASES, p. 574

BROMIDISM

See DRUG ERUPTIONS; *and* PSYCHOSES: TOXIC INFECTIVE PSYCHOSES

BROMIDROSIS

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Definition

198.] Malodorous sweating is usually, although not invariably, associated with hyperidrosis. In some races the smell of the sweat is more pronounced than in others. Probably the odour of each individual is characteristic, although in one it may be much more noticeable than in another. There is some doubt if it is due entirely to the secretion of the sudoriparous glands and there is reason to believe that, in part at any rate, it is associated with the secretion of the sebaceous glands; certainly the smell is often more pronounced in individuals with greasy skins.

Nature of secretions of sweat glands

It is known that there are two kinds of sweat glands—the eccrine glands which are distributed over the whole surface of the body, and the apocrine glands which are found only in the axillary, mammary, inguinal and circumanal regions. The apocrine glands are larger than the eccrine and of somewhat different structure; the eccrine glands function from infancy, but the apocrine become active later in life and not before puberty. The secretion of the eccrine glands is chiefly water and sodium chloride (and lactic acid after muscular exertion); that of the apocrine is more complex and contains fatty substances which are, or may become, odoriferous and which probably have some relation to sexual life. In women the secretion of the apocrine glands is liable to be more pronounced during menstruation. If profuse sweating is brought about by hot-air baths on successive days it is found that the secretion of the first day is more unpleasant in odour than that of the following days, the earlier outpouring being mingled with dirt, epithelial debris and bacteria. Although, therefore, bromidrosis may be a personal characteristic, it is to a certain extent due to the accumulation of perspiration and its consequent decomposition on the body or clothing: in short, lack of cleanliness is largely responsible. Fatty acids, such as caproic and caprylic acids, cause the peculiar odours of the axillary sweat. Certain drugs and other substances are also excreted by the skin and may give rise to characteristic smells, e.g. asafetida, musk, copaiba, sulphur, garlic and onions. There are also various diseases which have a typical smell due probably to alterations in the sweat, e.g. the 'sour' smell of acute rheumatism and the peculiar smells of smallpox and typhoid.

Sweating feet

The term bromidrosis is sometimes, though incorrectly, applied solely to a localized affection of the feet in which there is a particularly penetrating, nauseating and sometimes overpowering stench which makes life a misery both to the sufferer and his immediate neighbours. Hyperidrosis is usually present and in addition there is a liability to resulting changes in the skin of the feet—redness, soddenness and perhaps septic dermatitis. Walking may become difficult or impossible. The smell is due to contamination of the sweat with certain micro-organisms. Generally there is some accompanying disturbance of the general health, and predisposing causes are flat foot—a common precursor of hyperidrosis—want of cleanliness and the use of unsuitable footwear, e.g. rubber boots which prevent evaporation.

Treatment

Scrupulous cleanliness is the first necessity. Baths should be taken regularly, special attention being paid to the cleansing of the axillae, the perineum and the feet. Frequent changes of underclothing are required and woollen garments should not be worn next to the skin. Cotton socks which can be boiled are desirable. Boots and shoes which have become contaminated should be discarded. If hyperidrosis is a marked antecedent measures should be taken to deal with this.

Lotions

A lotion of aluminium chloride (4 to 10 per cent), or of mercuric chloride (1 part in 2,000 parts of 25 per cent industrial spirit), will be found useful for the axillae or palms. The lotion of aluminium chloride should not be applied to the axilla immediately after using a depilatory.

X-rays

If the hypersecretion of sweat is persistent, treatment by X-rays with a view to diminishing or abolishing the activities of the sweat glands must be considered. If flat foot is present appropriate remedial measures should be employed. When the skin of the feet has become red, sodden and septic, foot baths containing potassium permanganate (1 in 4,000) should be used twice a day, the feet being carefully dried and lightly powdered afterwards. Boric and salicylic acids are valuable remedies in bromidrosis of the feet.

Salicylic acid - - 10 grains
Boric acid - - 120 to 240 grains
French chalk - - to 480 grains

Cleansing and powdering should be continued for a long time as relapses readily occur. Stronger remedies such as chromic acid and formalin are best avoided.

Bromidrosiphobia

Bromidrosiphobia is a condition in which an uncalled-for dread of personal smell is present. It is fostered by advertisers who seek to call attention to the virtues of a particular soap or remedy. Like other phobias it may be extremely difficult to eradicate and may call for psychological investigation and therapy.

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BRONCHIAL SPIROCHAETOSIS

See BRONCHIECTASIS, BRONCHIOLECTASIS AND BRONCHIAL SPIROCHAETOSIS, p. 682

BRONCHIECTASIS, BRONCHIOLECTASIS AND BRONCHIAL SPIROCHAETOSIS

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I.—BRONCHIECTASIS

1.–AETIOLOGY

199.] It has often been stated that cough is the chief factor in producing bronchiectasis (βρόγχος, bronchus; ἔκτασις, dilatation), but its effect is to compress the lungs and bronchi and *not* to distend them. In some circumstances cough, and certainly the forced inspiration afterwards, may be an aggravating cause, but heavy smokers, chronic bronchitics and others with long-standing cough do not tend to develop bronchiectasis, and cough should be regarded as the result rather than the cause of this disease. The primary cause is disease which weakens the walls of the bronchial tubes: for example, an impacted foreign body producing partial obstruction of a bronchus causes secretion to accumulate and produce local inflammatory changes and ulceration. In addition, air has not free access to these tubes so that during inspiration the increasing negative pressure is not met by a full inrush of air but by stretching of the affected bronchi and corresponding lung tissue. The effect of this localized increase of negative pressure is chiefly seen in the weakest part; the lung tissue or bronchial tubes stretch either with resulting emphysema or with bronchiectasis or both. In these conditions the primary cause is inspiratory and not expiratory.

Apart from the presence of a foreign body within the bronchi, partial obstruction to a large bronchial tube by an aneurysm or growth will tend to cause bronchiectasis. Complete obstruction causes collapse of the lung.

The bronchial tubes may be injured by broncho-pneumonia, especially recurrent attacks, or by chronic tuberculosis or fibrosis resulting from empyema, abscess, or injury to the lung. Lobar pneumonia is an exudative condition which, except in extremely rare instances, does not lead to bronchiectasis. In some cases bronchiectasis is discovered without any known cause, and some of these cases may be congenital or due to collapse of part of a lung in early infancy.

2.—PATHOLOGY

Saccular type

There are two main types, the saccular and the cylindrical. The saccular type shows rounded dilatations of the tubes like arterial aneurysms. These dilatations or cavities contain pus which becomes very offensive if it is retained long before being expectorated; they are almost always multiple and sometimes resemble a bunch of grapes.

Cylindrical type

In the cylindrical form the dilatation is sausage-shaped and the affected tubes may be bunched together and look like the fingers of a glove; sometimes they are fusiform with tapering ends.

A large quantity of pus may accumulate before it reaches sensitive bronchial mucous membrane and starts a cough reflex. When the patient alters his position by stooping or lying down, pus may gravitate into healthy bronchial tubes; in this way cough and expectoration are often initiated by change of posture.

The effect of the disease is to destroy the structure of the tube which eventually becomes fibrous tissue. The adjacent lung tissue is also affected, the characteristic change being fibrosis which may spread deeply and affect a large area of the lung. There are also areas of collapse and in severe cases a chronic pneumonitis and sometimes even gangrene.

3.–CLINICAL PICTURE

Symptoms and physical signs

Symptoms depend largely upon whether or not the dilated tubes are dry; physical signs depend upon the type of bronchiectasis, its depth in the lung and the condition of the surrounding tissue. There may not be any symptoms and the condition may remain unsuspected until a sudden haemoptysis leads to examination with lipiodol and radiography. This type of bronchiectasis has been described as *forme sèche hémoptoïque.* On the other hand the symptoms—severe toxaemia with rapid pulse, high temperature, and cough with copious sputum, which may be so offensive that the patient cannot be nursed in a general ward—may be more distressing than those of any other disease.

There are of course various grades between these two extremes and the classical symptoms are as follows:

Cough and sputum

Cough is paroxysmal and occurs when the secretion reaches the healthy mucous membrane either owing to increase of quantity, or to change of posture.

The amount of sputum depends upon the degree and character of the bronchiectasis, and upon how long it has been retained in the bronchial tubes. It is said that if put into a specimen glass it separates into different layers, but the fact of clinical importance is that it is pus which can be kept sweet by free drainage but which becomes more and more offensive the longer it is allowed to remain stagnant. Toxaemia also is due to poor drainage; if the patient can cough up the sputum regularly before it has had time to stagnate there is no toxaemia.

Toxaemia

Pyrexia

In severe toxic cases the patient runs a hectic temperature. If cough and expectoration are sufficient to keep the tubes empty the temperature is normal. Recurrent attacks of fever are not uncommon and occur in cases in which pus accumulates in the tubes until, when it has reached a certain quantity, the patient begins to cough and, for a day or perhaps two, brings up a large amount of offensive sputum. The temperature then falls and the toxaemia disappears, but both gradually return as pus again accumulates.

Haemoptysis

It is now generally recognized that haemoptysis is the rule and not the exception in bronchiectasis. In the differentiation between pulmonary tuberculosis and bronchiectasis haemoptysis is sometimes mentioned as a point in favour of a diagnosis of tuberculosis; this is wrong. It is true that haemoptysis should always suggest tuberculosis because it is a much more common disease; but the patient with bronchiectasis is the more likely of the two to have haemoptysis. This is due to the associated fibrosis, for any fibrotic condition of the lung is likely to lead to haemoptysis and in tuberculosis it is the chronic fibrotic cases which are most prone to haemorrhage. Clubbing of the finger is almost always present in bronchiectasis and is most marked in the toxic form.

On examination of the chest the signs are those of fibrosis and sometimes, though rarely, of excavation. Adventitious sounds may be absent or present in different combinations according to the amount of secretion and the character of the surrounding lung tissue.

Complications

Fibrosis of the surrounding lung tissue is always present and in some cases there is extensive fibrosis of the whole lung. In severe cases there is ulceration which may go on to gangrene of the lung.

Broncho-pneumonia is unusual in the ordinary chronic cases except as a terminal condition.

Septic emboli leading to cerebral abscess may occur, but are relatively less common here than in abscess of the lung.

Pulmonary osteo-arthropathy

The septic absorption sometimes produces joint pains and occasionally a severe rheumatism occurs. In rare cases the ends of the long bones proliferate as a result of periostitis. The lower ends of the radii, ulnae and tibiae are most affected and the fingers are usually much clubbed. This condition, which is also seen in other chronic intrathoracic conditions, especially with mediastinal tumours, is known as pulmonary osteoarthropathy (see JOINTS, DISEASES AND DISORDERS).

4.–PROGNOSIS

Prognosis depends upon the degree of toxaemia, whether or not the disease is progressive, and to what extent it is amenable to treatment. If there is no toxaemia and the disease is not progressive, as in the dry form, the outlook is good; indeed the condition need not produce any ill effect and may be discovered unexpectedly at autopsy. If there is septic absorption and the condition does not yield to treatment the prognosis is bad. Most of these cases are slowly or intermittently progressive; the toxaemia increases and affects the heart muscle, and an early death is the rule. It is for this reason, and the fact that the nature of the sputum and the chronic toxaemia render the last few years of life intolerable, that even the most drastic treatment, if it offers any hope, may be justifiable.

5.–DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

In severe cases diagnosis does not present any difficulty; the paroxysmal cough, copious offensive sputum free from tubercle bacilli, and clubbed fingers make a characteristic picture. In the dry form, however, the patient is often in perfect health until a sudden haemoptysis occurs.

Radiography

Radiography is very important; indeed some cases and notably the *forme sèche hémoptoïque* cannot be diagnosed except by X-ray examination after the introduction of lipiodol into the bronchial tubes. There are three common methods of giving lipiodol—by the nasal route, by the oral route with a laryngeal syringe, or through the crico-thyroid membrane with a 20 c.c. syringe. All have their advocates and have proved successful. I prefer the crico-thyroid route as it avoids the unpleasant taste in the mouth and the choking or vomiting which are not uncommon with the other methods. In the case of small children it is usually necessary to give an anaesthetic, and the oral route is then quite satisfactory.

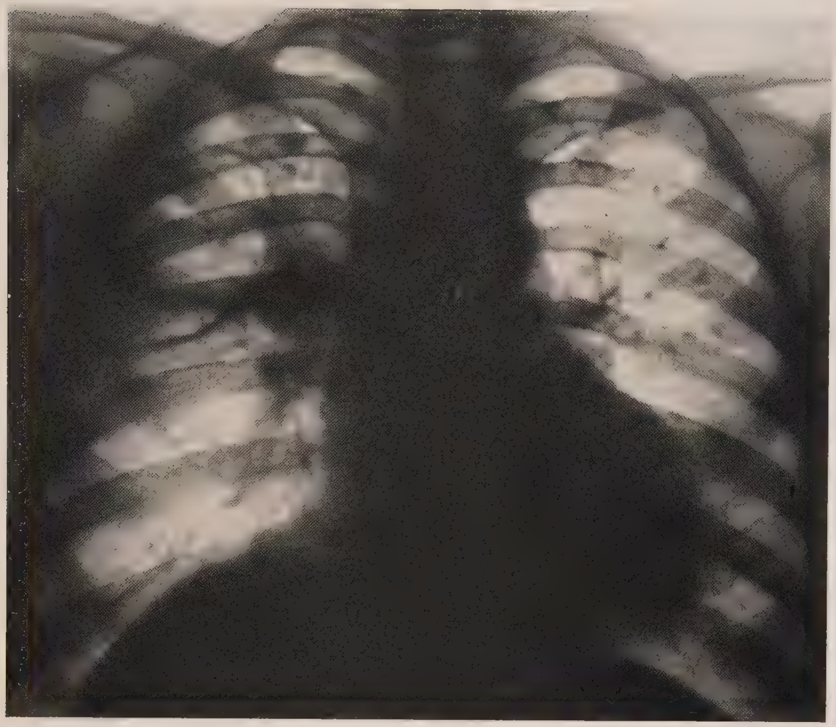
Introduction of lipiodol

To give lipiodol by the crico-thyroid route, the skin is cleansed in the usual way and 0·25 c.c. of a 2 per cent solution of procaine hydrochloride (novocain) injected intradermally through a very fine needle in the mid-line over the crico-thyroid space. Half a cubic centimetre of a 5 per cent solution of cocaine is then injected through the anaesthetized skin into the trachea. This usually produces cough and should therefore be done quickly, with a larger needle which is removed immediately after making the injection, to avoid the risk of its breaking. The lipiodol, which has previously been warmed, is then drawn into a 20 c.c. syringe the piston of which is worked by turning a screw. In most cases 10 to 15 c.c. of lipiodol are sufficient but in extensive bilateral cases it may be necessary to use as much as 30 c.c. It is important to avoid giving too much or it may appear in the X-ray film as a homogeneous mass. The patient should lie on a couch and inclined to the right or left according to the side it is desired to reach with the lipiodol. In bilateral cases he reclines on the right side for half the injection and on the left for the other half. The needle of the syringe is pushed into the trachea through the crico-thyroid membrane over the anaesthetized area and the handle of the syringe is then turned anti-clockwise in order to draw air into the syringe and show that the needle is really in the trachea. The handle is then turned slowly in the opposite direction to force the oil into the trachea. Two or three times during this procedure the handle should be again turned anti-clockwise and a small quantity of air drawn in, not only to show that the needle is still in the trachea, but to relieve the pressure in the syringe, which is apt to break, owing to pressure, if the oil is introduced too quickly. It should not take more than one minute to give 20 c.c. and patients rarely complain of any discomfort.

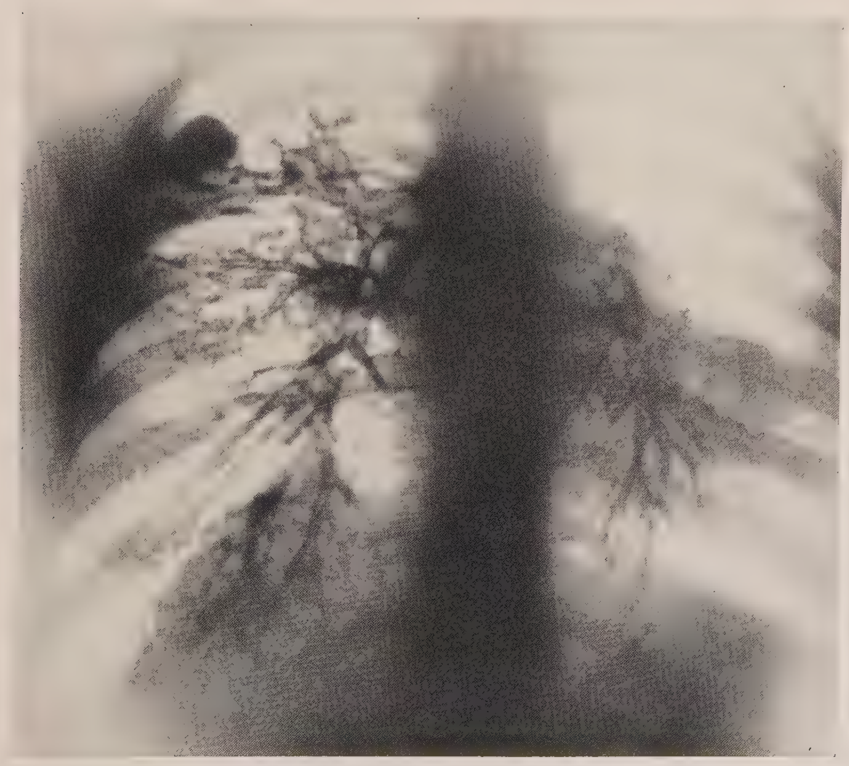
The radiograph is taken directly after the lipiodol has been introduced and it is important to have a lateral as well as an antero-posterior film in order to determine the exact site of the lesion and the number of lobes affected.

Diagnosis from tuberculosis

Certain cases resemble pulmonary tuberculosis and indeed the two diseases may be associated; the correct diagnosis of one does not therefore exclude the presence of the other. There are essential differences between tuberculosis and bronchiectasis. First, in any case in which the sputum is definitely purulent, failure to find tubercle bacilli after a thorough search does not exclude tuberculosis, but it is very strong evidence against it. Sputum is not often offensive in tuberculosis nor is it so copious as in bronchiectasis except in cases of extensive cavitation when the diagnosis is obvious. Secondly, tuberculosis usually affects the upper, and bronchiectasis the lower, zones of the lung. Thirdly, clubbing is comparatively rare in tuberculosis and when it does occur appears as curving nails rather than as the definite drumstick clubbing which is so characteristic of bronchiectasis and congenital heart disease. Toxaemia,



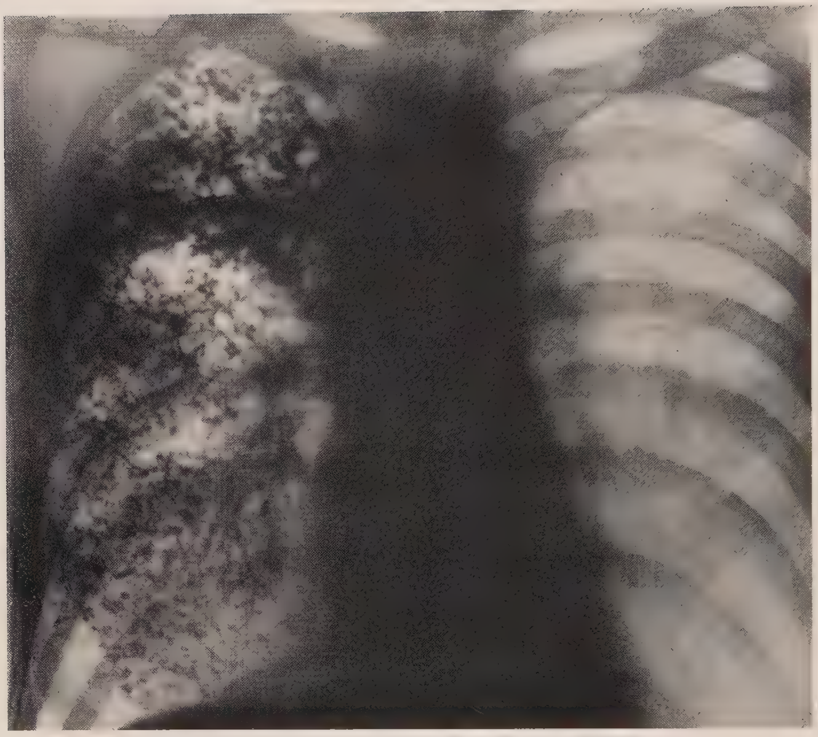
A.—Before lipiodol. Shows apical fibrosis but no definite cavity



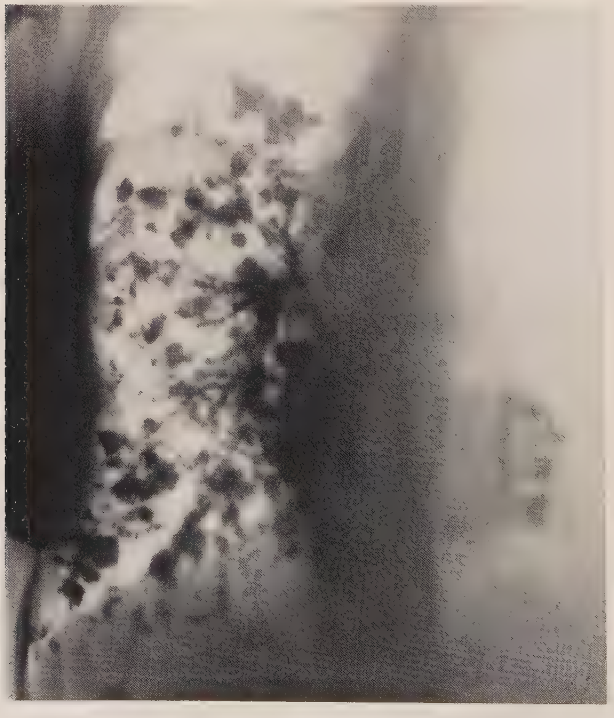
B.—After lipiodol. An apical bronchiectatic cavity is now seen

PLATE XIII

[*To face p.* 686



A.—Apical bronchiectasis after pneumonia. The case had previously been diagnosed as abscess



B.—Scattered saccular bronchiectasis of R. lung. There is also some bronchiectasis of L. lung. A case suitable for medical treatment

PLATE XIV

wasting and haemoptysis are as common in bronchiectasis as in tuberculosis.

From abscess of lung

Abscess of lung has been confused with bronchiectasis as in this condition the sputum may be offensive and copious and there is early clubbing of the fingers. In abscess, however, the X-ray appearances are different and lipiodol does not enter the abscess cavity. The sputum contains elastic fibres, the history usually reveals a definite cause for the abscess, such as a recent operation on the nose or throat, and the condition is more acute. Abscess may form as the result of bronchiectasis.

From empyema

A small empyema which has ruptured into the lung may resemble bronchiectasis and may be the cause of it. Here again the history and X-ray findings usually indicate the correct diagnosis.

From bronchitis

A condition known as putrid bronchitis has been described but it is doubtful if such a condition exists apart from bronchiectasis. Sputum in chronic bronchitis may be offensive, especially if there is associated ulceration, as in carcinoma, abscess, or gangrene of the lung. Lipiodol will show whether or not there is any dilatation of the tubes in a case of bronchitis.

6.–TREATMENT

Before treatment is begun, a thorough investigation should be made to determine the exact site and extent of the disease and whether there is partial obstruction of a bronchus by tumour, aneurysm, or foreign body. As well as the history, clinical and bronchoscopic examination, X-ray films should be taken in the lateral and antero-posterior positions both before and after the introduction of lipiodol. The throat, nose and sinuses must also be carefully examined. It is essential to exclude the presence of a foreign body, the removal of which will cure the patient.

Hygiene

The general health of the patient must be maintained by fresh air, regular routine, good food, relief of symptoms and treatment of associated conditions, such as disease of the nose or sinuses.

Treatment may be discussed under the following headings: (1) Removal of a foreign body if present in a bronchus, or attempt to relieve bronchial obstruction due to other causes. (2) Simple medical methods—posture, drugs, tonics, general management. (3) Simple mechanical methods—artificial pneumothorax, aspiration through a bronchoscope. (4) Surgical treatment—phrenic nerve paralysis, thoracoplasty, incision and drainage, cauterization, ligature of pulmonary vessels, lobectomy.

Removal of foreign body

The entrance of a foreign body into the trachea is usually followed by immediate spasm with violent coughing and choking. In some cases, however, a large foreign body may enter the bronchi without producing any cough or even without the patient's knowledge. It may remain for months and cause no symptoms or only mild bronchitis.

Treatment consists in removing the foreign body through a bronchoscope. On no account should it be left even if the symptoms produced are only trivial. Bronchiectasis is a late result of an impacted foreign body, and when once it is well established the disease remains even though the foreign body is removed. With modern technique most foreign bodies can be removed with safety. It is rare for them to lodge beyond the secondary bronchi.

If the foreign body is inaccessible to the bronchoscope an attempt should be made to remove it by transpleural or transmediastinal operation. These operations should only be performed when the bronchoscopic method fails since they are dangerous and often fail.

Simple medical methods

The symptoms in bronchiectasis are entirely due to the accumulation and decomposition of sputum in the dilated tubes; if the tubes are well drained the symptoms are relieved. Owing to the destruction of the sensitive mucous membrane in the affected tubes the cough reflex is not excited until a quantity of sputum has accumulated or until it gravitates into healthy bronchi owing to the patient changing his position.

In mild cases it may be sufficient for the patient to kneel on the bed with his hands on the floor and cough up as much sputum as possible every morning. Sometimes this must be repeated once or twice during the day. In more severe cases, continuous drainage is secured by placing the patient, face downwards, on a bed raised in the middle so that the body slopes downwards from the diaphragm to the mouth. Although the position is very uncomfortable, patients become accustomed to it and will often rest for many hours and even sleep in it. Continuous drainage in this manner sometimes leads to great and lasting improvement. It is particularly useful in the bilateral cases and should be given a thorough trial and not abandoned because results are not immediate. In many cases postural treatment, if given a sufficient trial, effects permanent benefit even if not an actual cure.

A boy of twelve had bronchiectasis affecting two lobes of the right lung and there was also a slight degree of bronchial dilatation at the base of the left lung as shown by X-ray after lipiodol injection. A right pneumothorax was induced and at first appeared to be successful. The temperature became normal, toxaemia disappeared, sputum was reduced to about an ounce a day and was no longer offensive; the boy gained weight and strength. After about six months the symptoms returned and it became clear that owing to the amount of adherent pleura an efficient pneumothorax could not be maintained. The patient was not seen for eighteen months, after which he was re-admitted to hospital. He was then coughing up fifteen to twenty ounces of foul sputum a day and was extremely toxic and ill. Temperature and pulse were much raised, his urine contained albumin, he had toxic diarrhoea and in addition to large bronchiectatic cavities in the right lung there was great extension of the disease in the left lower lobe. It seemed that he could not live for more than a few months and his parents decided to take him home, where we arranged for him to have continuous postural drainage, by keeping him on his face in a sloping bed. Except for creosote, which was given to reduce the smell of the sputum, he had no medicinal treatment. Diet at first consisted largely of milk because he was unable to take solid food without vomiting. As he improved the diet was increased. A year later he had lost all toxic symptoms and had gained thirty-two pounds in weight. The only symptoms were morning cough and about half an ounce of sputum. Two and a half years later he was working as a tradesman's errand-boy entirely free from cough and sputum. The ultimate prognosis in such a case is doubtful but it is certainly better than in cases with similar improvement from thoracoplasty. He has not yet had haemoptysis; this is unusual and he is liable to have one. The bronchiectatic cavities are still open though now dry, and may become reinfected. On the other hand it is possible that the cavities may remain dry and he may continue to keep well. This case is exceptional because of the extreme severity of the symptoms, but it shows that simple medical treatment does offer a very real chance of improvement.

Drugs

Inhalants

Drugs are of very little value except to relieve symptoms and for their tonic effect. Garlic has been advocated but its only value is to change the smell of the sputum. Creosote is the best deodorant but it is not effective if quantities of sputum continue to decompose in large cavities. It has some value as an expectorant. Two to five minims may be taken in capsule form, four or more times a day but is better given by inhalation in a creosote room. Crude creosote is burnt in a brazier and the patients sit round and inhale the fumes. At first they are very irritating to the eyes but patients get used to them and after a time can stay in the room for an hour or more. This method can hardly be used in a private house owing to the smell and to the fact that it clings to the walls and furniture.

Tonics

Tonic treatment has some value, but symptoms such as dyspepsia and anaemia are usually due to toxaemia and disappear when this is successfully treated. Convalescence may be helped by a stimulating tonic. Dyspepsia or simple debility may best be treated by a tonic such as:

Solution of strychnine hydrochloride – – –	3 minims
Dilute nitro-hydrochloric acid – – –	15 minims
Glycerin – – – – –	30 minims
Compound infusion of gentian – –	to ½ fl. ounce

Dose: half a fluid ounce in a little water before meals.

In the case of anaemia the following mixture will often be sufficient:

Arsenical solution – – – –	3 minims
Iron and ammonium citrate – – –	5 grains
Tincture of calumba – – – –	10 minims
Water – – – – –	to ½ fl. ounce

Dose: half a fluid ounce in water after meals.

If, however, there is much deficiency of haemoglobin large doses of iron should be given. Sixty or more grains of Blaud's pill a day is an effective method of giving iron. Liver is also helpful in the treatment of anaemia following sepsis. Liver soup may be made by cutting up a pound of calves' liver into small squares, adding it to 30 ounces of water and bringing to the boil. It is then allowed to simmer for an hour and after straining a teaspoonful of marmite is added and well stirred. The treatment is set out in detail in the article on ANAEMIA (Vol. I, p. 408).

Alcohol

A little alcohol before or during meals will often aid digestion and promote convalescence, but the best pick-me-up of all is an abundance of fresh dry air and cheerful surroundings.

It should be borne in mind that these methods of improving the general health are of value only after the cause of the toxaemia has been removed and that no amount of tonics or fresh-air treatment will avail while pus remains stagnant in the bronchial tubes.

Pneumothorax

Artificial pneumothorax is rarely successful in bronchiectasis, largely because there are almost always adhesions but also because the tough fibrous tissue prevents a satisfactory collapse of the bronchiectatic cavities. In some, even bilateral cases, pneumothorax is completely successful, in others it produces immediate results but the symptoms return as contraction of pleural adhesions gradually obliterates the pneumothorax cavity. Artificial pneumothorax for bronchiectasis is not advisable except in a few cases in which the disease is unilateral, but unsuitable for lobectomy. When successful, it may have to be maintained permanently because any attempt to re-expand the lung is followed by a return of symptoms.

If owing to adherent pleura it is impossible to obtain sufficient collapse to control the symptoms, the refills should be stopped as it is useless to keep up an inefficient pneumothorax.

In some toxic cases a temporary pneumothorax may relieve the symptoms and sufficiently improve the general condition to make lobectomy possible and render the operation much safer.

An effusion did not occur in any of my bronchiectasis cases treated with artificial pneumothorax, although it was a very frequent complication in patients with tuberculosis. This leads to the conclusion that these effusions are true tuberculous exudates and not directly due to the pneumothorax.

Aspiration

Aspiration through a bronchoscope often gives immediate relief and improves the general condition of the patient so that lobectomy can be successfully undertaken. Some patients obtain so much relief from aspiration that they return again and again in spite of the discomfort of passing the bronchoscope. It is especially useful when swelling of the bronchial mucosa prevents proper emptying of the tubes. Permanent results are not probable, but bronchoscopic aspiration is undoubtedly the best method of dealing with a bilateral case which cannot be controlled by simple posture.

Surgical treatment

Paralysis of the phrenic nerve has often been undertaken as a means of treating bronchiectasis. The results, however, are disappointing even if there is a considerable rise in the height of the paralysed dome of the diaphragm. In a few cases improvement or even complete relief of symptoms has followed, but the great majority do not show any benefit.

One result of the paralysis is to weaken the force of the cough and the patient may find increased difficulty in emptying the dilated tubes and be actually worse as a result of the operation. For this reason crushing the nerve is preferable to evulsion, as the result is only temporary and can always be made permanent by evulsion if the symptoms have been relieved by the crushing. As a preliminary to thoracoplasty phrenic evulsion is undoubtedly useful.

Thoracoplasty

Thoracoplasty is not a good operation in bronchiectasis because it very rarely produces sufficient collapse to close the bronchial cavities and it does not remove the disease. Nevertheless in some cases it has proved completely successful; one of my patients who had the operation in 1918 for severe bronchiectasis is now well and has been completely free from symptoms except for three attacks of haemoptysis.

In most cases, however, thoracoplasty gives little if any benefit. Those who regard surgical methods as the only possible means of giving real relief in severe cases of bronchiectasis point out that life is intolerable for the patient who has to undergo postural treatment and cough up quantities of foul sputum for the rest of his life. They say that the risk of death from the operation is well worth running in order to avoid such a life. But although death from the operation may be preferable to such a life there are other dangers from the operation besides death. If the whole of the diseased area can be excised a cure results, but if there is some bronchiectasis in another lobe or in the other lung there may indeed be temporary improvement, but every chance of the disease progressing and leaving the patient in a worse state than before.

In thoracoplasty it is the exception rather than the rule for bronchiectatic cavities to close, and the patient often becomes definitely worse as a result of this operation.

Lobectomy

Lobectomy is the best treatment. Formerly the danger of this operation was so great that it was rarely if ever justified. Under modern technique the operation risk has been reduced enormously and in the successful cases cure is complete. The most suitable case for lobectomy is that in which the lower lobe of one lung only is affected. If there is bilateral disease the removal of the worst lobe may give relief, but cannot cure the disease. The whole of one lung has been successfully removed in cases in which more than one lobe is affected and this does not seem to be appreciably more dangerous than removal of one lobe. Cases with bilateral disease have been reported in which a lobe from each lung has been removed.

In bad toxic cases of bronchiectasis the operative mortality for lobectomy is about 20 per cent and in the best cases about 6 per cent. Taking good and bad cases together, the operation mortality is about 14 per cent. No doubt this will, in time, be still further reduced: it was 80 per cent some ten years ago. It is very important to prepare a patient for operation by a preliminary course of medical treatment and to clear the bronchial tubes as much as possible by postural treatment and if necessary by aspiration through a bronchoscope.

Lobectomy is the only treatment which removes the disease, and if successful it cures. In considering the advisability of operation, and taking into account the misery produced in bronchiectasis by bouts of pyrexia, general malaise, and more especially the foul-smelling and copious sputum, the risks of lobectomy are not very great.

In the dry haemoptoic form treatment is rarely necessary except during the actual haemorrhage. If, however, the attacks of haemoptysis are severe and frequent, lobectomy is the best treatment and in this dry type of case the risk of the operation is small.

Summary of treatment

In any case of bronchiectasis the cause should be thoroughly investigated and it should always be remembered that there may be a foreign body, the removal of which will often cure the disease. Treatment must not be delayed until a severe bronchiectasis has been established, for this will persist and produce symptoms even after the foreign body has been removed.

Lobectomy is the only cure in most cases. The operation is not without risk and therefore should not be undertaken unless the disease incapacitates the patient sufficiently to justify this risk or is progressive so that more severe symptoms and incapacity may be anticipated.

If the disease is not progressive and the symptoms are not sufficient to justify lobectomy, the bronchial tubes should be kept as dry as possible by postural drainage. This method occasionally leads to permanent disappearance of symptoms and in most mild cases gives sufficient relief to enable the patient to lead a normal life.

If lobectomy is contra-indicated because the disease is bilateral, postural drainage with the possible addition of periodic bronchoscopic aspiration is indicated.

Artificial pneumothorax is rarely successful. The only indication for it is a unilateral case when lobectomy is contra-indicated or the patient unwilling to take the risk. Artificial pneumothorax may occasionally relieve the toxic symptoms and so help to prepare a patient for lobectomy.

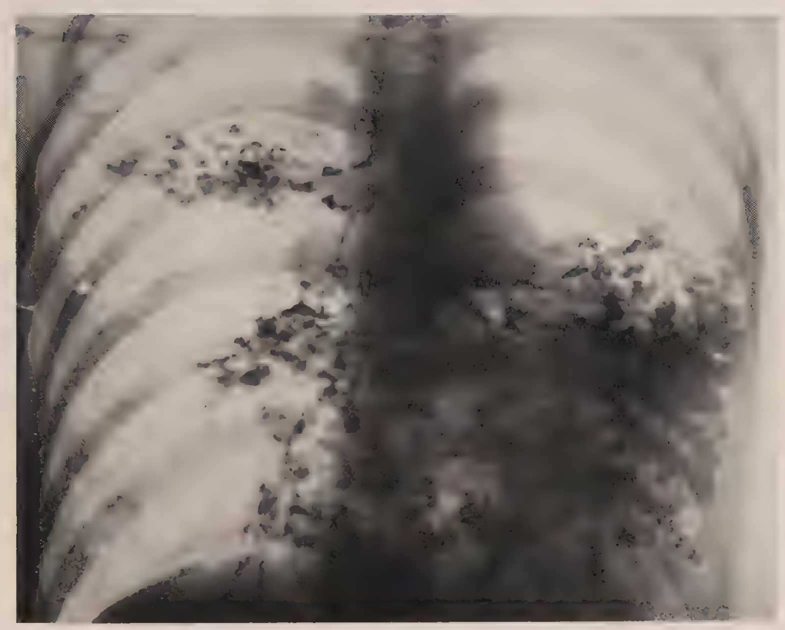
Bronchoscopic aspiration is useful as an adjunct to postural treatment, to empty the dilated tubes and so remove or lessen toxaemia and render the patient better able to stand the shock of lobectomy. It often gives temporary relief but symptoms almost invariably return.

Thoracoplasty has in a few cases cured the symptoms. It is, however, a bad operation in bronchiectasis.

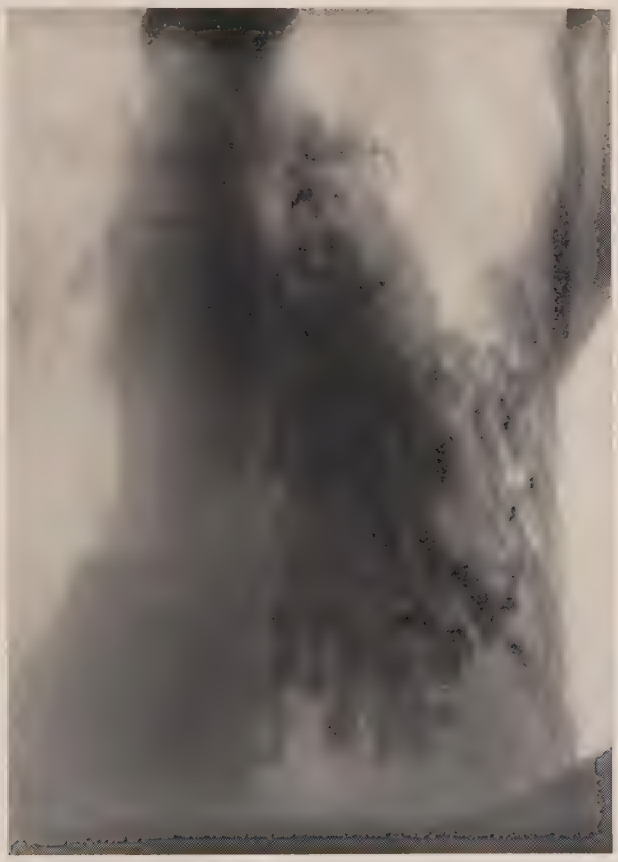
Phrenic evulsion rarely relieves the symptoms and may increase them.

Incision and drainage, and cauterization or ligature of the pulmonary vessels have been tried but are dangerous and have given place to the more modern method of lobectomy.

As in all other chronic diseases the general health of the patient should be maintained by fresh air, suitable exercise, diet, and tonic treatment.



A.—Left basal bronchiectasis. Suitable for lobectomy



B.—Showing failure of thoracoplasty to close the cavities

PLATE XV

II.—BRONCHIOLECTASIS

200.] This is an uncommon disease which may affect young children suffering from some infection, e.g. measles or whooping cough. It is usually an acute condition of both lungs and was described by J. W. Carr in 1891. The lungs present a honeycombed appearance which is due to a number of small bronchiectatic cavities. A congenital form of bronchiolectasis due to malformation has been described.

Symptoms The symptoms are pyrexia, wasting, cough, and expectoration except in very young children by whom the sputum is swallowed. Occasionally the disease becomes chronic and may last for three or four years and in this case there are great clubbing of the fingers, paroxysmal cough and moist sounds over both lungs. These chronic cases, however, are really bronchiectasis because the larger tubes become involved even if the disease starts as a bronchiolectasis. The prognosis is bad and death usually occurs from acute broncho-pneumonia.

It is possible that a temporary dilatation of the bronchioles may occur in association with measles, broncho-pneumonia or other acute infections in childhood and be followed by recovery. These cases, however, remain undiagnosed.

There is no treatment for the chronic variety, or honeycomb lung. It must, however, be distinguished from the localized bronchiectasis which may occur in young children as in adults.

III.—BRONCHIAL SPIROCHAETOSIS

201.] This condition was described by Castellani, who in 1906 found that in some cases of bronchitis in Ceylon and India spirochaetes were present in the sputum in large numbers. The mucous membrane of the bronchial tubes became swollen and, in a few cases, small patches of gangrene have been described. There is no dilatation of the bronchial tubes. Cases have been reported in different parts of the world. Some were found in the armies in Europe during the War and it was suggested that they contracted the disease from Asiatic or African soldiers. It appears to be mildly infectious, but no serious epidemics have been recorded.

Diagnosis The diagnosis is made from the presence of spirochaetes in the sputum of a patient suffering from cough, expectoration, and haemoptysis. At first cases are usually confused with tuberculosis and it is the continued absence of tubercle bacilli from the sputum which leads to a suspicion of some other disease.

Acute form In the acute form the symptoms are those of acute bronchitis, but the sputum is often blood-stained and contains spirochaetes. As a rule recovery takes place in three or four weeks, but relapses are not uncommon.

Chronic form

In the chronic form there is cough with a considerable amount of sputum and sometimes with mild haemoptyses. Bouts of pyrexia due to acute exacerbations are common as in cases of ordinary chronic bronchitis.

Treatment

Treatment is not satisfactory. In the acute cases rest in bed and expectorant mixtures and soothing inhalations are all that is needed. In the chronic form potassium iodide may relieve the cough if the sputum is tenacious and difficult to expectorate, but no medicinal treatment appears to be of any value. Arsenical preparations have not proved beneficial in this condition although much was expected of them.

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BRONCHIOLECTASIS

See Bronchiectasis, Bronchiolectasis and Bronchial Spirochaetosis, p. 693

BRONCHIOLITIS

See Bronchitis and Broncho-pneumonia, pp. 699 and 708

BRONCHITIS
AND
BRONCHO-PNEUMONIA

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Reference may also be made to the following titles:

BRONCHIECTASIS
COLDS
EMPHYSEMA OF THE LUNGS
IMMUNITY AND IMMUNIZATION
INFLUENZA
PNEUMONIA, LOBAR

202.] Infections of the bronchial mucous membrane are very common in countries in the temperate zones in which there are rapid changes in temperature and humidity. There seems little doubt that the mucous membrane is damaged by each attack and thus rendered more liable to further infection.

Gaskell showed that the virulence of the infecting organism may vary in a remarkable degree and at present no method of controlling this virulence is known. We are no less helpless in preventing the spread of infection in everyday life, but better education of the public in spread of 'droplet infection' and better hygiene and ventilation are undoubtedly important factors in prophylaxis.

The resistance of the patient to infection of the respiratory tract varies considerably from time to time, and the essential factor which modifies this natural resistance still escapes our knowledge. It is, however, known that cold and chill, food insufficient both in quantity and quality, overwork and excesses of all sorts, especially as regards alcohol, diminish the natural resistance of the body to respiratory infections. The 'acute cold' or coryza, probably due to a filter-passing virus, definitely disposes to bronchial infection.

The following types of acute bronchitis are recognized: acute catarrhal, acute suppurative, and acute fibrinous (Hoffmann's) bronchitis.

1.–ACUTE CATARRHAL BRONCHITIS

Aetiology

It is common in the elderly, and in children, especially when debilitated by rickets, dentition and specific fevers. Seasonal variations are marked; it occurs in the autumn and whenever there are sudden changes of temperature. 'Chill' from cold and wet commonly appears in the history, especially in sedentary workers and those living in hot atmospheres, who are exposed to the weather when going to and from their work. Specific fevers, especially measles, whooping cough and typhoid, are often accompanied by bronchitis. Coryza with a downward spread of the infection, and debilitating conditions, such as influenza, nephritis, diabetes mellitus, gout, rickets, cardiac conditions, and carcinoma, are frequent antecedents; and irritant vapours such as ether, chlorine, sulphur dioxide, nitric acid fumes and ammonia are of occasional importance. Finally, there is the 'chesty diathesis', and the fact that bronchial infections tend to run in families.

Bacteriology

The pneumococcus is the organism most commonly found; the streptococcus, *Micrococcus catarrhalis*, *B. influenzae* and Friedländer's bacillus are also often present.

Morbid anatomy

The mucous membrane is at first red and swollen and later desquamates: there is congestion and leucocytic infiltration of the submucosa and bronchial glands.

Clinical picture

Symptoms commence with a coryza or with mild malaise, cough and dyspnoea. Hoarseness is often present. The temperature varies between 100° and 101° F. The cough is dry, hard and painful for the first two days, becoming looser, with muco-purulent sputum during the succeeding days; sleep is often interrupted by the cough. There is a good deal of pain referred to the back of the sternum. The temperature and acute symptoms usually settle after the fifth day.

Physical signs in the early stages are emphysema with sibili and rhonchi later changing to loose crepitations and coarse rhonchi when the sputum is more liquid. Definite pleurisy is uncommon unless there is an actual broncho-pneumonia. The sputum is at first scanty and sticky, later becoming muco-purulent and finally mucoid. Heart failure is a not uncommon complication in the aged, and delirium tremens occurs in alcoholics.

Treatment

The patient should be put to bed at the earliest possible moment: this is the most important part of the treatment and neglect of this simple precaution may result in a broncho-pneumonia. The room should be warm and well-ventilated; in institutions, a 'tent' should be put at the top of the bed. The bowels should be opened with a dose of cascara and kept active with a daily laxative, such as liquid paraffin or senna; strong aperients should be avoided. During the first two or three days, when the cough is hard and painful, a bronchitis kettle to moisten the air is soothing.

Diet

Plenty of hot fluids should form part of the diet, tea, lemon and orange drinks with glucose. Liquid foods such as Horlick's malted milk, ovaltine and beef-tea should be given at first, and then light solid diet as the appetite improves.

Local applications

A linseed or kaolin poultice to the front of the chest is very comforting and seems to ease the cough and loosen the mucus. Inhalation of a fine oily vapour, such as oils of pine and cajuput from an 'apneu' vaporizer working from an oxygen cylinder, is very comforting.

Drugs

During the dry stage the cough should be controlled with a sedative linctus, such as Gee's, in sufficient dosage.

Compound tincture of camphor	equal parts.
Oxymel of squill	
Syrup of tolu	

Dose: one tablespoonful at first and then two teaspoonfuls every four hours. Appropriately smaller doses should be given to children.

Diamorphine hydrochloride – – –	$\frac{1}{16}$ grain
Apomorphine hydrochloride – – –	$\frac{1}{32}$ grain
Dilute hydrocyanic acid – – –	$2\frac{1}{2}$ minims
Syrup of virginian prune – –	to 60 minims

Dose: one teaspoonful every four hours.

An alkaline mixture is useful in loosening the sputum and promoting perspiration for the first three or four days.

Potassium citrate – – – –	20 grains
Sodium bicarbonate – – – –	20 grains
Spirit of nitrous ether – – – –	15 minims
Syrup of orange – – – –	120 minims
Distilled water – – –	to 1 fl. ounce

Dose: one fluid ounce, in water, every four hours.

When the sputum is muco-purulent and cough less painful, an expectorant is useful.

Tincture of ipecacuanha – – –	15 minims
Ammonium carbonate – – – –	$2\frac{1}{2}$ minims
Sodium chloride – – – –	10 grains
Spirit of ether – – – – –	20 minims
Syrup of anise – – – – –	60 minims
Distilled water – – – –	to 1 fl. ounce

Dose: one fluid ounce, in water, every four hours.

In the later stages, if there is an excess of mucoid sputum

Dilute sulphuric acid – – – –	20 minims
Atropine sulphate – – – –	$\frac{1}{150}$ grain
Solution of strychnine hydrochloride – –	$2\frac{1}{2}$ minims
Syrup of lemon – – – –	60 minims
Distilled water – – – –	to 1 fl. ounce

Dose : one fluid ounce, in water, every six hours.

When convalescent, a tonic such as Easton's syrup, or the proprietary preparation metatone, should be taken for a fortnight.

Specific treatment

Vaccines are useless in the acute stages but the sputum should always be examined bacteriologically.

If the patient has had previous attacks of bronchitis a course of autogenous or stock vaccine throughout the winter months should be given as a prophylactic for two years, e.g. anticatarrhal vaccine (Parke, Davis & Co.), 0·05 c.c., 0·1 c.c., 0·2 c.c. at weekly intervals, 0·3 c.c., 0·4 c.c., 0·5 c.c. at fortnightly intervals; and then repeat 0·5 c.c. at monthly intervals throughout the winter months.

At the onset of the acute stage, injections of non-specific antigens to increase leucocytosis are sometimes dramatic in cutting short the attack. Antibacsyn (Antibody Products Limited), a preparation of euglobulin from ox-serum, dose 2 c.c. intramuscularly, and colloidal manganese butyrate, 1 c.c., are occasionally efficacious.

2.–ACUTE SUPPURATIVE BRONCHITIS

(Suffocative Catarrh)

Aetiology

203.] This condition is rare but occurred in epidemic form among British troops during the Great War in 1916 and 1917. The overcrowding in huts and dug-outs, together with the severe winter of 1916–17, were undoubtedly predisposing factors in this epidemic.

Bacteriology

Bacillus influenzae was found most commonly, often in pure culture in the 1916–17 epidemic. The pneumococcus and streptococcus and also *Micrococcus catarrhalis* have been reported in other cases.

Morbid anatomy

A very extensive inflammation of the smaller bronchi occurs with the production of much fibrinous exudate and many pus cells, so that the bronchi are filled with thick, purulent fluid. Broncho-pneumonia and oedema of the lungs are usually found post mortem.

Symptoms The onset is abrupt, usually occurring in young males apparently in good health. There is a high temperature with much toxaemia; cyanosis is an early and striking feature. The sputum is at first streaked with blood and soon becomes greenish, consisting of almost pure pus; it may amount to 6 fluid ounces in the twenty-four hours. Well-marked toxaemia and delirium with loss of sphincter control supervene. Medium bubbling râles are heard throughout all lung fields.

Prognosis The mortality is high, about 50 per cent in severe cases, death taking place in three days from the onset. In non-fatal cases the disease lasts for three to six weeks and convalescence is slow.

Sequelae Chronic bronchitis and emphysema, diffuse fibrosis of the lung and bronchiectasis are common sequelae.

Diagnosis The rapid onset of extreme dyspnoea and well-marked cyanosis with profuse purulent sputum and absence of patchy dullness are striking and serve to differentiate the condition from broncho-pneumonia.

Treatment Cases should be isolated and treated as infectious. In addition to the treatment given under acute catarrhal bronchitis, oxygen should be administered from the onset. Tincture of digitalis, 45 minims daily, should be given in view of the likelihood of cardiac failure. Venesection is valuable and should be repeated when cyanosis becomes severe or when there are signs of failure of the right ventricle.

3.–ACUTE FIBRINOUS BRONCHITIS

(HOFFMANN'S, OR PLASTIC BRONCHITIS)

204.] This is a rare condition in which casts of the bronchi are coughed up.

Aetiology The cause is unknown. It may occur at any age and in previously healthy persons. It is often associated with asthma but also occurs as a complication of such acute conditions as typhoid fever and pneumonia.

The casts consist of mucin and fibrin, containing eosinophils, other leucocytes and occasionally Charcot-Leyden crystals; Curschmann's spirals may be found. Friedländer's bacillus or the pneumococcus are the most common organisms.

Morbid anatomy At necropsy the casts may be seen *in situ*; the bronchi may be inflamed or pale and unaffected. There is always well-marked emphysema.

Clinical picture The chief characteristic is an acute attack of what appears to be asthma, associated with a temperature up to 100° F.; the paroxysms, however, resist all the usual remedies, including adrenaline, atropine and morphine. The physical signs are those of asthma, prolonged expiration with sibili, but may be confined to one lobe. Occasionally the air-entry over the affected lobe is absent; in the later stages, when the casts are loosening, a flapping sound—the *bruit de drapeau*—may be heard.

After two to five days in the status asthmaticus, the sputum becomes looser and the casts are coughed up. These are generally from the smaller bronchi and bronchioles and their nature may not be appreciated unless they are examined floating in water. Occasionally the casts are from bigger tubes and may be three to six inches long. The symptoms abate as soon as the casts are expectorated. Second attacks occur in some cases, usually in the same part of the bronchial tree.

Diagnosis The condition is differentiated from severe asthma by the presence of fever, failure to react to adrenaline, and by the production of casts.

Prognosis The condition is seldom fatal but is always very alarming and further attacks are not uncommon.

Treatment It is essential to loosen the sputum so that the casts may be coughed up; for this purpose hot drinks, especially tea, should be given in large quantities and steam inhalations frequently employed; intranasal oxygen should be administered to relieve the intense dyspnoea.

At the onset apomorphine may be valuable.

Apomorphine hydrochloride	$\frac{1}{16}$ grain
Dilute hydrocyanic acid	2½ minims
Diamorphine hydrochloride	$\frac{1}{12}$ grain
Syrup of virginian prune	to 120 minims

Dose: two teaspoonfuls at onset and then one teaspoonful every six hours.

Aromatic spirit of ammonia	10 minims
Potassium iodide	10 grains
Potassium bicarbonate	20 grains
Sodium bicarbonate	20 grains
Syrup of tolu	60 minims
Distilled water	to 1 fl. ounce

Dose: One fluid ounce, followed by half a pint of hot fluid, for three doses.

4.–BRONCHO-PNEUMONIA

(Capillary Bronchitis, Lobular Pneumonia)

205.] Broncho-pneumonia is an acute inflammation of the smaller bronchioles with patchy inflammatory consolidation of one or more lobules of the lungs. It may be either primary or secondary to other conditions.

Primary broncho-pneumonia Primary broncho-pneumonia is common in infancy and the early years of childhood, in which typical lobar pneumonia is rare. The most important organism is the pneumococcus; other organisms are the streptococcus, Friedländer's bacillus, *Micrococcus catarrhalis*, and *B. tuberculosis*.

Secondary broncho-pneumonia Secondary broncho-pneumonia may occur in the following circumstances:

(1) (*a*) As a sequel to bronchitis; (*b*) in association with specific fevers —e.g., measles, pertussis, influenza, diphtheria, scarlatina and typhoid—

or with gastro-enteritis, rickets, acute middle-ear disease and debilitating conditions, such as carcinoma, anaemia and diabetes mellitus.

Aspiration type

(2) The aspiration or septic type, associated with the inhalation of septic materials when the cough reflex is abolished may occur:

(*a*) After operations, especially operations on the nose and throat, and when there is much vomiting, as with emergency abdominal operations; (*b*) in conditions of coma and diseases of the nervous system—e.g. cerebral haemorrhage, uraemia, concussion and bulbar palsy; (*c*) by direct spread of infection (i) from diseased lung—e.g. bronchiectasis, abscess or haemoptysis; (ii) from the oesophagus—e.g. carcinoma; (iii) from below the diaphragm—e.g. subphrenic or liver abscess; (*d*) from inhalation of irritating vapours—e.g. ether, sulphur dioxide and the poisonous gases in war-time (phosgene, chlorine and mustard gas).

Hypostatic type

(3) In conditions causing pulmonary collapse a low-grade infection takes place, eventually resulting in broncho-pneumonic consolidation. These conditions are most common in: (*a*) senile bedridden patients, e.g. with fracture or cerebral thrombosis; (*b*) patients undergoing upper abdominal operations, resulting in immobility of the diaphragm; (*c*) patients with bronchial obstruction from plugs of mucus, foreign bodies or tumours.

There are all grades of severity from a small patch of broncho-pneumonia to a widespread consolidation with abscess formation or gangrene. An empyema is not an uncommon complication in severe cases.

Clinical picture of primary broncho-pneumonia

In primary broncho-pneumonia the patient is usually under three years of age; the onset is sudden and is often ushered in by vomiting or a convulsion. The temperature rapidly rises to 103° to 105° F. and is remittent in type, settling by crisis or more commonly by lysis in five to ten days. The pulse-rate is usually over 120 and the respirations may be 50 to 70 per minute. The child looks flushed and ill with a dry hard cough and obvious wheezing; the alae nasi are working and there is often an expiratory grunt. There may be recession of the intercostal spaces and xiphisternum with inspiration. The infant is usually restless and distressed; cyanosis may be well-marked after the first day or two. In the most severe cases, however, the child is pale with a lilac tint of the ears and fingers, and is very quiet and listless.

The physical signs at first are those of bronchitis with rhonchi and sibili; fine crepitations are heard over a wide area when the bronchioles are affected, and there may be patches of tubular breathing and impaired percussion note. Marked impairment of note is unusual, except in widespread consolidation, because of surrounding emphysema. Coarse, bubbling crepitations are heard when the secretions become more liquid after the first few days. Sputum is not produced as it is swallowed by the infant; it is often seen in the vomit.

Diagnosis

Meningismus with head retraction is common, and diagnosis from meningitis may be difficult without examination of the cerebrospinal fluid.

Once the acute stage is over the infant's condition rapidly improves;

indeed it is surprising to see an apparently moribund infant, some twenty-four hours later, crying lustily for food.

Prognosis

The mortality rate is low in this, the primary form. Pallor, drowsiness, increasing pulse-rate, weak cough and the absence of crying are of grave significance.

Secondary broncho-pneumonia

Secondary broncho-pneumonia may vary from the mildest type, resembling catarrhal bronchitis, through a prolonged suppurative condition of both lungs and pleurae, lasting many weeks, to the most acute fulminating influenzal pneumonia, with death in thirty-six hours. As a rule the onset is more gradual than in the primary form; there is bronchitis, increasing temperature, pulse and respiration rate, with cyanosis and signs of patchy consolidation.

Prognosis

Individual cases must be assessed on the findings, and general rules do not apply. In infants, especially with rickets and enteritis, the mortality rate is about 50 per cent in the hospital class and about 25 per cent in private practice. In the aged or debilitated patient the mortality is in the region of 50 per cent. In the aspiration or hypostatic pneumonia, it is about 75 per cent. Serious manifestations are increasing pulse-rate with falling blood-pressure, e.g. pulse-rate greater than the systolic pressure in millimetres of mercury. Cyanosis or lividity, delirium, drowsiness, a poor cough, and extensive consolidation are all grave signs.

Complications and sequelae

In the primary form there is either complete resolution or death; empyema and pericarditis are rare. In the secondary form empyema occurs more commonly; meningitis, pericarditis and purulent arthritis are rare.

Tuberculous broncho-pneumonia probably starts as an initial tuberculous infection.

Pulmonary fibrosis and bronchiectasis are not uncommon sequelae, especially after whooping-cough and measles; the latter are also liable to be followed by a flare up of quiescent tuberculous mediastinal glands resulting, in a fair proportion of cases, in tuberculosis of the lymphatic, respiratory, or nervous systems within the next twelve months.

Treatment

The general routine treatment of bed, warmth and good nursing apply as given under acute bronchitis. Fluids should be given freely and the alkaline mixture suggested in acute bronchitis (see p. 698) should be administered four-hourly until the urine becomes alkaline. The sputum should be examined at the earliest moment in every case to learn the type of organisms present and to exclude the presence of tubercle bacilli.

Serum

If a pure culture of pneumococcus is grown, the type should be ascertained. Anti-pneumococcus serum B.P.C. is of definite value in the primary form if given in the first seventy-two hours.

Oxygen

Intranasal oxygen should be given continuously from the onset, to lessen the respiratory efforts of the patient. Infants tolerate this surprisingly well if the catheter is lubricated with a little 2 per cent cocaine-vaseline.

In the post-operative and hypostatic cases, associated with pulmonary collapse, oxygen containing 5 or 7 per cent of carbon dioxide should be given intranasally for a few minutes three or four times a day to stimulate the respiratory centre and promote expansion of the lung bases.

Drugs

Opium and its derivatives may be given cautiously for sleep in the early stages, but should be entirely avoided if there is cyanosis or much congestion of the lungs.

Up to 45 minims of tincture of digitalis daily should be given from the onset to all patients over sixty years of age, and in severe cases when signs point to cardiac strain. Strophanthin, $\frac{1}{250}$ grain intravenously, is the best method of getting the heart 'digitalized' in an emergency.

Stimulants

Alcohol should be given to alcoholics from the onset, in the form and dosage to which they are accustomed. As stimulants, coramine (1 c.c.), cardiazol (1 c.c.), caffeine and sodium salicylate 1 grain, or strychnine hydrochloride $\frac{1}{32}$ grain should be used when the heart shows signs of flagging.

Venesection

Venesection is very valuable with increasing cyanosis and pulmonary congestion.

Emetics

Tincture of ipecacuanha or ammonium chloride in emetic doses is useful in infants when the bronchi are full of mucus, provided they are not too feeble.

Treatment of empyema

If an empyema develops it should be aspirated, first making a two-inch incision in the skin down to the intercostal muscles. This wound should be kept open by packing with emulsion of acriflavine B.P.C., to prevent suppuration of the chest wall and to allow further aspirations. Surgical drainage is indicated as soon as the pus has become shut off.

Vaccines

Vaccine therapy is useless in the early stages but in prolonged cases small doses of autogenous vaccine are sometimes of striking benefit.

Tuberculous broncho-pneumonia will be considered under the title LUNG DISEASES: TUBERCULOSIS.

5.–CHRONIC BRONCHITIS

(*Synonyms.*—Chronic Catarrhal Bronchitis; Chronic Bronchitis and Emphysema)

Definition

206.] A chronic inflammatory condition of the bronchi almost invariably associated with a greater or lesser degree of emphysema.

Aetiology

Chronic bronchitis may be associated with: (1) A previous bronchitis or broncho-pneumonia. (2) Occupational conditions, by the inhalation of various dusts and fumes, e.g. in mines, gas and chemical works, sewers and so forth. (3) Conditions associated with chronic cough: inhalation of tobacco smoke, asthma, arrested pulmonary tuberculosis, mouth breathing. (4) Climatic conditions: fog and damp, exposure to the weather. It may also be associated with hyperpiesia, chronic cardiac and lung affections, gout, syphilis and alcoholism.

The disease is more common in men than in women; it develops in middle life, after forty-five years of age, and tends to be familial in incidence.

Bacteriology

The usual catarrhal organisms as given under acute bronchitis are found. Most common, perhaps, is a mixture of the pneumococcus, *Micrococcus catarrhalis* and streptococcus.

Morbid anatomy

There is atrophy of the mucous membrane with fibrosis of the submucosa; emphysema is always prominent, and usually there is evidence of failure of the right heart.

Clinical picture

At first there are repeated mild attacks of bronchitis in the winter months; later the cough and sputum become chronic in the winter and disappear in the warm weather; later still the cough and dyspnoea persist the whole year round.

The patient typically tends to be thick-necked, plethoric, stout and broad-chested. There is often a tinge of cyanosis in the ears. Polycythaemia is common. The chest tends to be barrel-shaped with a wide intercostal angle, rigid ribs, and is permanently fixed in the inspiratory position. Respiration is carried out with the accessory muscles and diaphragm; the chest expansion is usually very poor, under 1½ inches at the level of the fourth rib, and 1 inch at the level of the epigastrium. The vital capacity is reduced to about 50 per cent of the normal, mainly because of the great increase in the residual air. There is a frequent cough with the production of from one to four ounces of muco-purulent sputum in the twenty-four hours. Wheezing is present on the least exertion.

On examination of the chest there is always emphysema with diminution of the cardiac and liver dullness; the breath sounds are feeble with prolonged expiration and there are rhonchi and sibili with coarse mucous râles at the bases, when the secretion has not been expectorated. The right heart tends to be hypertrophied with an accentuated pulmonary second sound, but is dilated in the later stages, and cardiac congestion of the lungs adds to the respiratory embarrassment. In the late stages, congestive heart failure or a broncho-pneumonia closes the scene.

Diagnosis

Diagnosis presents little difficulty as a rule, although it must be borne in mind that pulmonary tuberculosis may be associated with the condition, and carcinoma of the lung may cause similar symptoms. These should be excluded by examination of the sputum and an X-ray examination of the chest. When there is a large quantity of sputum, a lipiodol examination should be made to exclude bronchiectasis.

Course and complications

The course is steadily downhill with seasonal variations. In advanced cases the bronchitis persists throughout the summer. Emphysema is part of the syndrome, and asthma, bronchiectasis and cardiac failure are common complications.

Prognosis

Prognosis is serious in the majority of cases, as treatment is not sought until the late stages when the reserve of respiratory efficiency is nearly exhausted. Patients may carry on with their work with increasing dyspnoea for many years.

Prophylaxis The public should be educated in regard to the seriousness of the condition, which causes a very grave economic loss of working hours to the community. The medical profession should take steps to lay down definite instructions regarding the mode of living when the earlier cases are first seen.

Treatment
Climate For the wealthy there is no doubt that life may be prolonged, even in advanced cases, by spending the winter months in a warm, dry climate. Egypt, the north coast of Africa, the Riviera and certain parts of Switzerland have long enjoyed a reputation for this type of case.

Occupation If possible the conditions of work should be altered, e.g. instead of a dusty trade an out-door occupation may be available; a bus-driver should be given a closed vehicle.

Habits The inhalation of tobacco smoke should be absolutely forbidden. For this purpose a pipe is preferable to cigarettes, which should always be smoked, if at all, through a holder. Alcohol, especially beer, should be reduced. In the stout, plethoric type the diet should be limited in quantity; potatoes, bread, puddings and pastries should be eliminated and butter and fatty foods should be restricted in amount. Green vegetables and fruit should form a large part of the diet. Clothing should be light but warm, especially on the chest and loins. For the out-door worker a good pair of boots, a cardigan and an oilskin coat are cheap investments.

Vaccines The ordinary stock vaccines are definitely of value if given in proper dosage. Although autogenous vaccines are probably more efficacious, their preparation is too costly for routine use. It is advisable to examine the sputum bacteriologically before prescribing a vaccine. It must be remembered that the immunity conferred by a vaccine is only of short duration, from four to eight weeks; if the vaccine is given when the patient is beginning a 'cold', or in too large dosage, an attack of bronchitis may be provoked. Experience shows that better results are obtained by repeated injections of small doses than by two or three injections of a larger quantity. Although the administration of a vaccine does not necessarily prevent bronchitis, the attacks are often less frequent and less severe in patients so treated.

An anticatarrhal vaccine (Parke, Davis & Co.) is in common use and contains in each cubic centimetre:

M. catarrhalis	50 millions	*B. septus*	50 millions
B. pneumoniae	50 millions	*B. influenzae*	250 millions
Pneumococcus	250 millions	*Streptococcus*	25 millions

The following dosage is recommended:

0·05 c.c., 0·1 c.c., 0·2 c.c., at weekly intervals.
0·3 c.c., 0·4 c.c., 0·5 c.c., at fortnightly intervals.

Repeat 0·5 c.c. at monthly intervals throughout the winter months, or throughout the year in advanced cases.

If an attack of bronchitis occurs within forty-eight hours of the injection, the next dose should be reduced to one-fifth, and subsequent doses cautiously increased.

Breathing exercises

Much of the dyspnoea is due to the emphysema, resulting from chronic cough and wrong methods of breathing. Although in advanced cases this emphysema is organic and due to degeneration of the pulmonary elastic tissue, in the earlier cases the greater part is due to functional emphysema.

In natural breathing inspiration is caused by the contraction of the inspiratory muscles (diaphragm and intercostals), whereas expiration takes place passively from the elastic recoil of the lungs. With catarrh the bronchioles are narrowed and a valvular action takes place, whereby although air gets into the alveoli the elastic recoil is insufficient to empty them properly. The more dyspnoeic the patient becomes, the more active the inspiratory effort and a vicious circle results. The aims of breathing exercises should be to get rid of the functional emphysema by concentrating on the expiratory phase, to acquire automatic diaphragmatic breathing at the expense of the upper-chest type of breathing, to relax the spasmodically contracted intercostal and accessory respiratory muscles and to increase the mobility of the chest wall and correct kyphosis.

The patient should be taught simple exercises, which will fulfil these requirements, by a masseur trained in the subject. Examples of such exercises are to be found in a booklet, *Physical Exercises for Asthma*, published by the Asthma Research Council, 1934, price 2s. Patients should practise these exercises for at least five minutes night and morning.

The improvement in the dyspnoea is often well-marked and a surprising degree of chest mobility may be acquired. A chest expansion of 1 inch at the 4th rib may be increased to 4 inches, even in elderly and chronic cases.

Treatment by means of exercises is physiological and therefore sound. It should be more widely advised and practised.

Drugs

Drugs should be given with two objects in view, to decrease the useless cough and to liquefy and promote expulsion of the sputum.

Tincture of stramonium – – –	12½ minims
Potassium iodide – – – –	7½ grains
Compound tincture of camphor – –	45 minims
Aromatic spirit of ammonia – – –	15 minims
Syrup of tolu – – – – –	60 minims
Distilled water – – – –	to 1 fl. ounce

Dose: one fluid ounce to be taken night and morning in a wineglass of water.

Sodium bicarbonate – – – –	10 grains
Sodium chloride – – – –	3 grains
Spirit of chloroform – – – –	5 minims
Anise water – – – –	to 1 fl. ounce

Dose: one fluid ounce to be taken on waking in the morning, followed by a glass of very hot water.

Special clinical types are:

Bronchitis sicca

Bronchitis sicca (*catarrhe sec* of Laennec); severe and obstinate spasms of coughing with the production of small pellets of sticky mucus.

Bronchorrhoea

Bronchorrhoea (pituitrous catarrh) is characterized by bouts of coughing with a very large quantity (up to 3 pints in the twenty-four hours) of clear, mucoid sputum. The condition may occur at intervals, although occasionally it is chronic. In one case quoted by Seyfarth, the vagus nerve on one side was embedded in a mass of tuberculous glands. Adrenaline and atropine should be tried.

Putrid bronchitis

Foetid or putrid bronchitis is described, but is invariably associated with some degree of bronchiectasis and should be classified under that heading.

6.–BRONCHIOLITIS FIBROSA OBLITERANS

207.] Bronchiolitis fibrosa obliterans is a rare condition resulting from the inhalation of irritating gases. As its name implies, the disease is characterized by connective-tissue proliferation in the bronchioles as a result of local injury; it is usually patchy and irregular in distribution, and the resultant changes in the lung, either collapse or emphysema, depend on whether the bronchiole is completely or partially occluded.

History

Bronchiolitis fibrosa obliterans was first recognized by Lange in 1901 and further described by Fraenkel in 1902 and 1909 and by Edens in 1906. As a result of the investigations on the pathology of war gas poisoning by the Chemical Warfare Service of the United States Army in 1920, Winternitz has shown that the condition can be produced in experimental animals by the inhalation of poisonous gases, especially phosgene and chloropicrin. Although only about a score of cases are reported in the literature, the condition is probably not so extremely rare and certain cases described as miliary tuberculosis with recovery may in fact be examples. Blumgart and MacMahon (1929) gave a good review of the subject and described five fatal cases. Ehrich and McIntosh in 1932 described three cases of Bright's disease in which obliterative bronchiolitis was present.

Aetiology and pathogeny

The essential lesion is damage to the bronchioles resulting in necrosis of their walls. This may be caused by: (*a*) Chemical vapours inducing necrosis of the bronchioles, with subsequent infection by bacteria. The poison gases, phosgene and chloropicrin especially, are the most important but cases have been described resulting from the fumes of nitric and hydrochloric acids, ammonia, arsenuretted hydrogen, etc., which are used in various industrial processes. (*b*) Bacterial infection, especially associated with measles, whooping-cough and influenza. Cases are described following acute or subacute bronchitis in the absence of any specific aetiological factor. The organisms most commonly found are haemolytic streptococci, pneumococci and influenza bacilli. Similar bronchiolar lesions may occur in Bright's disease and uraemia, in which fibrin formation in the lung, together with diminished resistance to infection generally, is common.

Morbid anatomy

The appearances closely resemble miliary tuberculosis, with tiny greyish nodules, 1 to 2 mm. in diameter, scattered throughout the lungs. With a hand lens, the nodules are seen to be irregular in outline with streaks of greyish fibrous tissue radiating into the surrounding lung. In the centre of the nodule a fine pore may be made out, representing the lumen of the bronchiole. There are patchy collapse and emphysema of the lung but the pleura is not commonly involved. The stellate character of the nodules and the absence of tubercles on the pleura differentiate the condition from miliary tuberculosis.

Histologically, in dogs experimentally poisoned with phosgene, there is an early patchy necrosis of the bronchioles, with great oedema of the lung and fibrinous deposit in the alveoli. Subsequently there is bacterial invasion of the necrosed areas with the formation of granulation tissue, which later becomes an organized mass of fibrous tissue that may block the bronchioles entirely or form crescents causing partial occlusion.

In man similar lesions are found and the fibrous tissue is seen spreading out into the surrounding lung. As healing takes place, new ciliated epithelium may line the bronchioles, which are twisted and distorted by scarring. With occlusion of the bronchioles, there is atelectasis and organization of the related alveoli; and in partial occlusion, as inspiration is stronger than expiration, a valve mechanism occurs resulting in emphysema of the lung involved.

Clinical picture

In most of the cases described the condition lasts three or four weeks and ends fatally. The onset is with a chill and the symptoms of acute bronchitis—namely, fever, dyspnoea, cyanosis and cough; there is little sputum. The acute phase then settles down with diminution of the dyspnoea and the temperature may become normal. After a latent period of a week or two, when the symptoms are mild, the dyspnoea, cyanosis and cough increase in severity; the temperature rises and there are many fine and medium consonating crepitations with expiratory sibili all over the chest; bronchial breath-sounds and patchy dullness are not found in the typical cases. The condition progresses till death takes place from asphyxia in one or two weeks.

Milder cases undoubtedly occur and those which exhibit the radiographic picture of miliary opacities throughout the lung, but clear up in a few weeks, are probably examples of the condition. In these the clinical course may be very benign with but slight evidence of toxaemia and few physical signs.

Diagnosis

In the acute cases described, the sudden onset of dyspnoea, cyanosis and the absence of bronchial breathing are typical of miliary tuberculosis; the X-ray appearances may be identical. Repeated examination of the sputum fails to demonstrate the tubercle bacillus, and of course retinal tubercles are not seen. In those cases which recover, the lesions as seen in the X-ray film gradually diminish over a period of weeks or months.

Prognosis

About twenty fatal cases are described in the literature. It is likely that the diagnosis will be made more frequently, especially on radiological evidence, as the condition becomes more widely recognized.

The subject is further considered under the title GASSING AND POISON GAS.

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BRONCHO-PNEUMONIA

See BRONCHITIS AND BRONCHO-PNEUMONIA, p. 701

BRONZING OF THE SKIN

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Reference may also be made to the following titles:

ACANTHOSIS NIGRICANS
ADRENAL GLAND DISEASES
ALKAPTONURIA
DERMATITIS DUE TO INJURY AND POISONING
DRUG ERUPTIONS
HAEMOCHROMATOSIS
HODGKIN'S DISEASE
PELLAGRA

208.] Cutaneous pigmentation may be congenital or acquired and its varieties can be classified according to the aetiology.

1.–PIGMENTATION DUE TO PHYSICAL AND CHEMICAL CAUSES

Physical causes of pigmentation are: sunlight, ultra-violet rays artificially produced, X-rays, and so-called Bucky rays from a 'soft' X-ray tube, heat, i.e. infra-red rays, or occasionally following repeated application of poultices; tattooing, or accidental impregnation of tar from the road as after motor accidents; and grit or powder after explosions or gunshot wounds.

Chemical causes of pigmentation are: arsenic, and the heavy metals, lead, bismuth, mercury and gold salts; silver causing argyria, formerly much more common when silver salts were used for irrigation of the bladder; the dermatitis which is produced by external irritants in susceptible persons. 'Berlocque' dermatitis—e.g. from the application of bergamot oil—is especially prone to be followed by hyperpigmentation, and it may be noted that this oil is used with more or less success to promote bronzing of depigmented areas in vitiligo.

Sun-bathing

The growing practice of sun-bathing renders this cause of bronzing the skin by far the commonest. This is undoubtedly a health-giving measure and, as scientifically applied in the Rollier clinic at Leysin, is one of the most potent of all therapeutic weapons in the prophylaxis and cure of tuberculosis of the skin in its various forms, bone and joint disease of tuberculous aetiology, acne vulgaris, chilblains, some types of anaemia, and debility in general. But it cannot be too strongly emphasized that in excess, or carelessly 'dosed', the rays of the sun, especially in tuberculous subjects, may light up latent foci in the lungs, with occasionally fatal results. For this reason the utmost circumspection is necessary and the dangers of irrational exposure should be widely advertised. Some individuals react quickly without much preceding erythema, whereas others respond but slowly or with much inflammation of the exposed parts. A considerable number do not pigment at all in the ordinary way, and may react by an undue production of freckles, a common stigma in the red-haired.

Melanin

The chemical substance responsible for bronzing or pigmentation of the normal skin is melanin which occurs as an amorphous deposit in the cells of the lower layers of the rete Malpighii. The mechanism of melanin production, and its composition, are discussed in the article on LEUCODERMIA. But here it may be recalled that melanin does not contain iron, and this distinguishes it from such colours as may be produced by extravasated haemoglobin and some of its derivatives.

Artificial radiations

The pigmentation produced by artificial sources of light does not differ in any essential respect from that due to the rays of the sun and appears to be governed by the same laws. It does not, however, attain the same depth, and no apparatus yet invented can produce the depth of bronzing which results from graduated exposure to the sun in the high Alps or on the sea-coasts at Biarritz or Algiers.

X-rays

Cutaneous pigmentation produced by X-rays varies with a number of factors of which the most potent is the degree of 'softness' of the rays. The so-called Bucky rays, which are derived from a special X-ray tube with a quartz (instead of glass) window, allow a relatively large number of these soft rays to pass and their application is commonly followed by pigmentation—often of some duration—of the exposed area.

Arsenical pigmentation

The early recognition of arsenical pigmentation is of great importance. Localized as a rule to the neck, flanks and abdomen, its distribution is patchy and there is a tendency to reticulate mottling. This configuration gives rise to the term 'dew-drop' and is highly characteristic of the condition. The colour varies from brown to sepia, with a slaty tinge, and is darker in those areas which are normally pigmented such as the nipples, groins and axillae. The 'dew-drops' are small unpigmented areas in the main pigmentary sheet. If of long duration the condition may be associated with a deficiency in the secretion of sweat and sebum, which renders the skin dry and harsh to the touch. The mucosa of the mouth and other recesses of the body escape, and this fact sometimes helps to distinguish it from the pigmentation due to Addison's disease.

Confusion between arsenical pigmentation and pityriasis versicolor should not occur, although both conditions are liable to affect the same body areas. In the latter (which never affects the mucous membranes), the cause—a delicate mycelium (*Microsporon furfur*)—can easily be demonstrated in the superficial horny layers in scrapings from the areas affected.

Other heavy metals

Pigmentation due to the administration of other heavy metals such as lead, bismuth, mercury and gold salts is much rarer, less pronounced and not so persistent. It is, however, more frequently associated with stomatitis, and a lead or bismuth 'blue line' on the gums just below the necks of the teeth will sometimes aid the diagnosis. Dermatitis due to therapeutic injections of bismuth preparations is by no means rare in skin and venereal disease clinics.

Treatment

No treatment other than lapse of time is of much value in the foregoing types of pigmentation, but unless the drug has been administered for years there is every prospect of gradual amelioration and eventual clearance.

Argyria

Argyria, the peculiar bluish-slate colour of the skin due in the past to frequent and continued bladder irrigation with dilute solutions of silver nitrate, or to the oral administration of silver nitrate pills for epilepsy, is now rare. It is due to the deposit of a silver salt in the basal cells of the epidermis and in skin appendages such as sebaceous and sweat glands, and owing to the reducing effects of light is always most prominent in the exposed areas. Its site therefore differs from those of arsenical pigmentation and of Addison's disease. Once deposited this pigmentation is almost permanent. It may affect the mucous membranes, especially of the mouth, and the sclerotics and periorbital skin. In America Gaul and Stand (1935) collected seventy cases of argyria due to the use of argyrol and colloidal silver preparations, but such an experience is not familiar to British practitioners.

Berlocque dermatitis

Berlocque dermatitis and pigmentation is an example of the combined effect of the sun or other source of ultra-violet rays and oil of bergamot, which is commonly present in eau-de-Cologne and other scented essences. Other oils that may be responsible are those of cedar, lemon, lavender, neroli and rosemary. It seems that benzene and alcohol may also produce a similar bronzing in the presence of sunlight, and the resulting stigmata have been studied with a view to their therapeutic use in leucodermia and other varieties of depigmentation. The history of a preceding dermatitis in the areas showing hyper-pigmentation—usually the face and neck—and following the exposure of the parts to sunlight, is usually sufficient to arouse suspicions of its nature and so prevent recurrences. If the cause is not recognized the dermatitis may prove very intractable, the pigmentation may persist for several months.

2.–PIGMENTATION DUE TO LOCAL SKIN CONDITIONS

Parasites

A common cause of such pigmentation is irritation of the pigment-bearing cells in the basal-celled layer of the epidermis by pediculi and organisms of the mycelial or mould groups. In chronic cases of lice infestation the skin may assume, especially in the covered areas, a diffuse dark brown or slaty-bluish pigmentation (phthiriasis, or vagabonds' disease). The cause of this in tramps and vagrants is usually evident both on the clothing and body hairs from the presence of scores, and sometimes hundreds of the parasites and their ova. Disinfestation of clothing in the sterilizer, and the local application of mild disinfectants, such as 10 per cent of sulphur or betanaphthol in olive oil or soft paraffin, are sufficient to remove the cause. Strong mercurial preparations are entirely unnecessary and frequently provoke intractable dermatitis.

Pityriasis versicolor

The diagnosis of pityriasis versicolor—characterized by fawn-coloured or brownish pigmentation of the chest and back and usually associated with superficial scaling and sometimes erythematous macules—is occasionally missed or ignored owing to absence of other symptoms. The experienced eye will have no difficulty in recognizing the condition, and the diagnosis is confirmed by examining microscopically a few scales in potassium hydroxide solution under a $\frac{1}{6}''$ objective (see FUNGOUS DISEASES).

Chronic inflammation of the skin

All chronic inflammatory diseases of the skin may be associated or followed by brownish pigmentation of varying depth and degree in the areas affected. Lichen planus especially of the legs, neurodermatitis, varicose eczema and syphilis share this propensity equally, but the diagnosis of the cause can seldom be made from the character of the coloration. Other factors and symptoms, the history and localization must be considered. The rarer causes of pigmentation associated with eruptions of various types include purpura, urticaria pigmentosa, acanthosis nigricans which is usually associated with malignant changes elsewhere, and Darier's disease (dyskeratosis follicularis vegetans).

Ichthyosis

The ichthyotic subject, in addition to his dry and persistent branny scales, usually presents a dirty brown discoloration, particularly of the extremities, from an early age. It varies with the degree of care and attention received and is not entirely due to disturbances of pigment metabolism. Much of it can be controlled by daily warm baths with a superfatted soap and the inunction of emollient ointments.

3.–PIGMENTATION DUE TO CONSTITUTIONAL CAUSES

Those diseases in which a systemic condition underlies and doubtless causes pigmentation cover a wide field and will always demand experience and careful investigation. At the head of the list stands Addison's disease (see Vol. I, p. 233). In the differential diagnosis it is obvious that chronic arsenical poisoning, with its attendant diarrhoea and vomiting, brachial and popliteal neuritis, progressive weakness and emaciation, will have to be primarily considered; but once the possibility arises and is realized a mistake could hardly occur.

Acanthosis nigricans, an exceedingly rare complication of carcinoma, is described in Volume I, page 75. The pigmentations, particularly marked on the abdominal skin, sometimes associated with abdominal tuberculosis, Hodgkin's disease, and some disorders of the blood and haemopoietic systems are in the same category.

Haemochromatosis

In haemochromatosis general bronzing occurs in much the same areas as those affected in Addison's disease. It can usually be differentiated by concurrent glycosuria. The tendency to pigmentation, which is due to excess of melanin in the epidermis, is probably the result of degenerative changes in the adrenal cortex. These are also observed in the liver and pancreas in such cases, and may end in a form of hepatic cirrhosis which can be detected manually.

In a comprehensive study J. H. Sheldon suggests a simple classification into two groups: (*a*) those in which the colour is bronze, and (*b*) those which display a bluish tinge, 'especially apparent in reflected light'. In the latter group histological investigation 'tends to show that the bluish or metallic tint is associated with the presence of haemosiderin in the deeper strata of the Malpighian layer'. In 15 cases of the 16 histologically examined in the other group, the bronzing was due to melanin. Glycosuria was present in 78 per cent in a series of 186 cases of the disease, but it tends to appear rather later in its course, and before the discovery of insulin was regarded as of 'ominous significance', since a fatal issue usually supervened within 12 months. 'Bronzing' with diabetes is still an unfavourable symptom, but there are records that by means of insulin 'control has been established for periods of several years'.

Ochronosis

Congenital predisposition plays an important part in the occurrence of two further types of cutaneous pigmentation—ochronosis, and xerodermia pigmentosa. In the former there are associated grey-brown or blackish deposits in the cartilages (visible in those of the ears), the sclera, and intima of the larger blood-vessels. Amorphous brown or yellowish deposits may occur in the epidermis and nails. The pigment is derived either from melanin or from that substance in combination with certain aromatic bodies, and homogentisic acid with melanin may be present in the urine. Alkapton, or phenol derivatives as in carbolic acid absorption, may be responsible for a very similar darkening of the urine on standing (see ALKAPTONURIA, Vol. I, p. 300).

Xerodermia pigmentosa

The 'bronzing' in xerodermia pigmentosa—due to the aggregation of innumerable brownish-yellow freckles—appears often in the child's first summer, on the face and other areas exposed to actinic light. These freckles are permanent and do not disappear in the winter. The following summer adds to their number, and soon small dry warty papules and minute telangiectases are associated in the clinical picture. A parchment-like character of the facial skin and atrophic patches about the eyelids lead to ectropion with the usual ocular complications. The general appearance of such a case is not unlike that met with in extensive X-ray dermatitis of long standing, or of the later changes in chronic arsenical dermatitis. In all three conditions there is furthermore a pronounced tendency to the development of cutaneous squamous-celled carcinoma in the small warty excrescences, and death from metastases is the usual fate in all pronounced cases of xerodermia pigmentosa. The cause is quite obscure and no treatment is of permanent avail.

Pellagra

Pellagra is another pigmentary condition in which sunlight may be regarded as at least a factor in production. It is endemic in Italy, Spain and the Tyrol, and occurs in small epidemics in the United States and in isolated instances in the British Isles. It is a systemic disorder associated with gastro-intestinal and mental disturbances, and with a form of dermatitis on the exposed parts of the face, neck and backs of the hands. Ensuing pigmentation of these areas with a fine peeling or branny desquamation may closely resemble the ordinary effects of local sunburn, from which they can only be differentiated by the associated symptoms, and the constant recurrences. The prognosis is bad in the well-developed and long-standing cases and even in the milder types there is said to be a mortality of from 5 to 35 per cent. The treatment of pellagra is fully discussed in the article under that title.

Endocrine disturbances

Finally, there may be considered a number of conditions in which the influence of endocrine abnormalities or dysfunctions is assumed to be a predominating factor in causing pigmentation.

Pregnancy

Slight variations of pigmentation are the rule in pregnancy, especially marked in situations such as the nipple areola. Some darkening of the skin of the face and forehead may ensue with each pregnancy, and regress during the period of lactation. In pronounced cases there may be distinct brownish and sometimes disfiguring patches of pigmentation with irregular outlines, and the condition is then termed chloasma. It may also occur in association with disease of the female genital organs (chloasma uterinum), and is then probably the result of irritation of the abdominal sympathetic system. There is no satisfactory direct treatment. Relief is dependent on termination of the pregnancy, by delivering at term or otherwise, and is usually marked when menstruation is resumed.

Menopause

Facial bronzing of less pronounced degree may occur at the menopause, and is then usually associated with symptoms suggesting a lack of endocrine balance. Such cases are exceedingly difficult to control, for few of the endocrine preparations other than those derived from the thyroid gland are really effective, especially when administered by the mouth.

Varying abnormalities of pigment distribution, both excessive pigmentation and vitiligo, may occur in toxic goitre. When it is remembered how closely the endocrine and sympathetic systems are linked together, increased pigmentation in hyperthyroidism may be assumed to have much the same pathological background as chloasma, Addison's disease and other conditions involving the abdominal sympathetic system.

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BRUCELLA INFECTIONS

See Abortus Fever, Vol. I, p. 68; *and* Undulant Fever, *Melitensis* and *Suis* Types

BRUISES

See Athletics and Athletic Injuries, p. 225

BUBAS

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See BLINDNESS, p. 448

BURNS AND SCALDS

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1.–DEFINITION

209.] Burns are produced by exposure of the body to some form of dry heat, scalds by exposure to some form of wet heat, for example, boiling water or superheated steam. Scalds are now far more frequent than burns, and they carry a much lower mortality rate.

2.–PATHOLOGY

(1)—General Features—Burns and Scalds

On exposure to excessive heat, the skin becomes coagulated and, according to the length of exposure and height of the temperature, the deeper structures are also more or less destroyed. Scalding by boiling water rarely produces more than coagulation of the superficial layers of the epithelium. Boiling fat produces necrosis of the deeper layers, and burning of the body by petrol, as in aeroplane and motor-car fires, produces some of the most severe injuries seen.

(*a*) *Post-mortem Changes*

When a person is trapped in a burning room, death is usually due to suffocation by the fumes, and poisoning by carbon monoxide. The burnt area may be small but the victim may be suffocated by smoke.

Duodenal ulceration

Acute ulcers in the duodenum may in rare cases appear in a few days; they have sharp-cut borders with little induration, and lie almost invariably in the second part of the duodenum opposite the ampulla of Vater; they have been widely ascribed to excretion through the biliary ducts of a hypothetical toxin formed in the body or absorbed from the burnt surface.

After less severe burns the internal signs are few, apart from general congestion of the viscera, acute bronchitis from irritation of the bronchi by the smoke and fumes of the conflagration, and cloudy swelling of the renal epithelium.

Medico-legal

A point of medico-legal interest is the effect of immersion of the body in boiling fluids. A fall into a vat of boiling water or fat is almost instantaneously fatal and the sudden coagulation and contraction of the muscles gives the body the crouching defensive attitude employed by boxers. This is called the ‘pugilistic attitude’.

Dupuytren’s classification

The extent of damage to tissue is measured by the degree of burning, according to Dupuytren’s classification. Most text-books adhere to it faithfully, as it is a register of great value.

(*b*) *First Degree Burns*

In burns of the first degree the heat has been sufficient merely to cause reddening of the skin without any destruction of tissues. This condition occurs at the edge of a more severe scald; apart from the small amount of irritation which it produces it is of very little significance. A more chronic form is often seen in those exposed for long periods to excessive heat (*erythema ab igne*). In stokers it is common, and it is a familiar sight on the shins of those who spend much time by their firesides. It is a mottled, brown discoloration with perhaps slight desquamation. Except for its unsightly appearance it is not of any importance.

(*c*) *Second Degree Burns*

The cuticle and the more superficial layers of the skin are killed by the heat, and exudation from the living cells of the cutis vera beneath causes the coagulated epithelium to be raised as blisters of clear yellow fibrinous fluid. This is the degree usually produced by boiling water. Small limited scalds of this and the third degree are those mainly of importance to the general practitioner, as they are very painful and disabling. Provided that gross infection does not supervene no scarring takes place, but, even after healing, the burnt area may show some permanent alteration in colour.

(*d*) *Third Degree Burns*

The epidermis is burnt off, exposing the corium which may be in part destroyed. The deeper parts of the sebaceous and sweat glands are intact and from these skin can readily grow, during convalescence, over the denuded area to meet the skin growing in from the edge.

This kind of burn is most often produced by burning petrol, boiling water rarely causing so much destruction. The pain and shock are greater in this than in any other degree of burn, not only because the cutaneous nerve-endings are laid bare by the loss of skin, but also because the deeper tissues are exposed, from which fluid is lost and toxic products are absorbed. Should this degree of burn be so extensive as to cover one-third of the total body surface, death is almost certain. Gross deformity is unusual, for unless infection supervenes, the raw surface will become covered with skin from the numerous sebaceous follicles scattered over the burnt surface. This new skin is usually thick, white and conspicuous, but scarring and contractions are not usually found.

In both second and third degree burns, shock is present in varying degrees of intensity, greater in burns of the third degree. It is produced partly by painful stimuli of the sensory nerve-endings, but for the most part by loss of fluid from the burnt area or by the action of certain toxic substances produced by the destruction of the proteins of the body. Of these toxic substances histamine, which produces a profound fall in blood-pressure and collapse, is particularly important.

(*e*) *Fourth, Fifth, and Sixth Degree Burns*

With the fourth degree the destruction extends to the subcutaneous tissue. In the fifth degree burning of the muscles and ligaments occurs. In the sixth and last degree all the structures of the part, including bone, are destroyed and the whole limb is charred.

These last three degrees of burns are generally produced by burning rather than scalding and usually require exposure to the flames for some time, as when a man is trapped in a burning car or aeroplane.

Charring of a limb, however, is not so productive of shock as extensive third degree burns. Convalescence is protracted because all the skin-forming elements have been destroyed, and the dead tissues must first be separated as a slough by granulation tissue, before epithelium can grow in from the healthy skin edge.

(2)—Special Types of Burns

Electricity

Electric burns are becoming increasingly common. They are usually inflicted by contact with a 'domestic' current of relatively low voltage. The burns are usually deep, and conform more or less closely to the area exposed. They are intractable in healing, and American writers have suggested that, when the burnt areas are relatively local and fairly deep, they should be excised bodily, and the clean wound so formed sutured. This greatly shortens convalescence, but suitable cases should be carefully selected, and the treatment should be carried out only in hospital, where a full aseptic technique is possible.

X-rays

X-ray dermatitis is produced by continued exposure to X-rays, and is becoming increasingly rare as more and more care is taken to shield the hands of the operator by lead gloves. Over-exposure to radium produces similar lesions. The early stages are marked by reddening and thinning of the skin and great irritation. The skin tends to crack, and the fissures so formed presage the onset of the second stage, in which slow, intractable ulcers appear on the site of preceding fissures. They resist all attempts at treatment and eventually become epitheliomatous ulcers. The treatment in the early stages is palliative, but, in the later stage, amputation may be necessary.

Sunlight and ultra-violet rays

Sunlight and ultra-violet light burns are usually of the first degree. They should be treated in the same way as scalds.

3.–CLINICAL PICTURE

Shock

The patient who has received a fairly extensive burn of the second or third degree complains of excessive pain and faintness. This initial shock is due to the enormous stimulation of sensory nerve-terminals in the denuded area, and passes off in two or three hours. In severe burns the pain and shock are so great that the patient may faint or vomit, and when the burnt area is large, death occasionally occurs in this early stage.

Toxaemia

The next phase is the onset of acute toxaemia. This appears in a few hours and lasts from six to twenty-four hours. It has been said to be largely due to loss of fluid by exudation through the burnt surface.

Diminution of blood-volume

During the toxaemic phase the blood-volume is diminished and the blood-pressure falls, owing to the gross dilatation and engorgement of all the splanchnic vessels. The patient is in a state of surgical shock; the face is pale and drawn; he is restless and very apprehensive; the pulse is rapid and of poor volume and the temperature may be subnormal; there may be a slightly raised red-cell count owing to the concentration of the blood.

Septic absorption

The third stage is the onset of toxaemia caused by septic absorption from the burnt surface. This occurs only when the burnt area is extensive and gross infection is present. It may appear a few days after the burn, and during this phase the signs and symptoms are those usually associated with an acute infection. The temperature is raised, often fluctuating widely; sweating and wasting are well marked; there is a polymorphonuclear leucocytosis of 10,000 to 15,000. The wound is obviously infected, its edges are oedematous, red and inflamed, and the discharge of pus from the granulating surface is profuse. This phase of the condition is rare now that early treatment is both more usual and much more effective than formerly.

Albuminuria

A mild albuminuria is not uncommon during the convalescence of a burnt patient. This has been ascribed to toxic degeneration of the renal tissues resulting from absorption of unknown toxins from the burnt surface.

Haematemesis

Haematemesis or death from perforation of a duodenal ulcer may very rarely occur by the tenth day in patients who have received severe burns which have been insufficient to cause earlier death.

Mortality

The mortality rate of all burns and scalds admitted to a large London hospital during the period 1894–8 was as high as 30 per cent. The burns were of course severe as otherwise the patients would not have been admitted to hospital. The rate at the same hospital during the period 1929–32 was only 2·4 per cent (Mitchiner).

The diminution in the mortality rate can be explained only by the substitution of protein coagulation by means of tannic or picric acid for the older treatment by warm baths and the application of greasy dressings.

4.–TREATMENT

(1)—First, Second, and Third Degree Burns

First degree

As first degree burns consist merely of a painful erythema of the skin without vesiculation, the treatment is simple and can often be dispensed with. The application of a cooling lotion such as evaporating lead lotion B.P.C. on a piece of lint, and the administration of aspirin at night, should be sufficient. No complications are likely to ensue.

Second and third degree

Second and third degree burns form the great majority of the more serious cases, and treatment must be prompt and efficient to spare the patient excessive pain and sometimes to prevent a fatal termination. The plan of treatment should be first to counteract the collapse due to pain, fright and exposure, secondly to combat the toxaemia from histamine absorption of the first few hours, thirdly to prevent infection and its complications, and finally to prevent deformity from contracture. This will occur in second and third degree burns only if infection causes delay in healing and further loss of epithelium.

(*a*) *First-Aid Treatment*

Danger of active interference

Active interference with the burnt area in the first few hours is usually unwise and often dangerous as it may lead to further collapse and even death. First-aid measures consist in giving a hypodermic injection of morphine sulphate $\frac{1}{4}$ grain and combating the shock by hot blankets and hot-water bottles. If the patient's nausea will permit it, fluids should be given freely by mouth. For patients with severe shock it may be necessary to give an intravenous transfusion of a pint of sterile physiological saline or 5 per cent glucose saline at body temperature. More often the administration of saline by means of a 'rectal' drip is called for, as this is not so difficult to perform in the patient's house. It is, however, less efficacious than the intravenous injection. Transfusion of blood may be necessary in very grave cases.

If the condition is not too serious, the patient should be transferred to a hospital or nursing home, as the treatment in the first few days is difficult and requires much organization. The practitioner should not, however, cut away blisters, nor should he apply oily dressings to alleviate pain; the first procedure encourages infection, the second renders subsequent treatment by tannic acid more difficult. Preliminary dressing of the wound with compresses soaked in 2 per cent tannic acid solution is the ideal treatment.

(*b*) *Tannic Acid Treatment*

Advantages

As soon as the patient's general condition permits, the burnt area must be treated with tannic acid solution. This is a protein coagulant and forms on the surface of the burnt area a dense black scab, beneath which healthy skin can be formed. If properly employed, the tannic acid treatment prevents infection, obviates repeated and painful dressings, is followed by less scarring, and shortens convalescence. The only difficulties in the technique are that the whole procedure must be most thorough and that careful attention is necessary for the first three or four days.

Anaesthetics and sedatives

The first step is the thorough cleansing of the burnt area. If this area is extensive and very painful, and if the patient is extremely apprehensive, a general anaesthetic must be given. In less advanced cases, complete cleanliness may be achieved if the patient is quietened by morphine. Adult patients may safely be given $\frac{1}{4}$ to $\frac{1}{3}$ grain of morphine sulphate hypodermically and, if necessary, 30 minims of tincture of opium orally. Between the ages of fifteen and twenty, the dose of morphine should not exceed $\frac{1}{4}$ grain, and between the ages of twelve and fifteen $\frac{1}{6}$ grain of morphine is the maximum dose (Mitchiner). In addition to morphine these patients may also be given 30 minims of tincture of opium. A rough indication of the safe dosage for children is that, over the age of one year, $\frac{1}{75}$ grain of morphine per year of age is the maximum dose, the tincture of opium being omitted. If the patient is not sufficiently insensitive after the half-hour or so required for the morphine to act, then a little gas and oxygen may be administered.

Preliminaries

The burnt area is first cleaned of any gross contamination and then washed over thoroughly with a soft cloth soaked in warm ether-soap solution. A scrubbing-brush should not be used as it causes unnecessary injury to the skin. Blisters should not be broken at this stage; if their surfaces are cleaned before they are ruptured the underlying raw area is spared a little additional infection. The skin is then wiped over with spirit and with ether under strict aseptic precautions; every tag of dead epithelium and blister must be removed. Particular attention should be directed to the edges of the burnt area, as small vesicles are very likely to pass unnoticed here. The cleaning should not be so vigorous as to cause bleeding, as the exuded blood raises the tannic acid crust and may favour suppuration. If, however, bleeding occurs and cannot be arrested by pressure with a warm moist sponge, it may be disregarded and the tannic acid applied in spite of it.

Tannic acid sprays

The method of applying the tannic acid varies; the best method is to spray a freshly-prepared 2 per cent solution of tannic acid in water over the raw area. This is done two or three times on the operating table, the excess of fluid being dried off by playing a hair-drying (hot-air) machine over the surface. The surface is then lightly wrapped in sterile lint and the patient is returned to bed, when the lint is removed and the spraying is repeated half-hourly, until the surface assumes a dark-brown colour, turning later to black. Between the sprayings the area is not bandaged but is exposed quite freely to the air, and over the burnt area an electric hot-air cradle is placed to dry the surface and to maintain the body temperature. As soon as the surface is black and shows a good hard coating, spraying is stopped and the patient is able to get up. The spraying does not usually cause more discomfort than a slight itching. The black crust should be inspected from day to day to make sure that infection has not occurred beneath it. If pus is seen oozing from one corner of the crust, an attempt should be made to localize it to that corner by picking off part of the crust to allow freer drainage, and a spirit dressing should be applied. If the whole scab is lifted up by pus, the treatment has failed, and the infection must be treated by hot compresses. In cases that are doing well the crust may be left to be thrown off by the body.

Burns should never be sprayed until they have been rendered as aseptic as is possible. If the damaged area is on the back as well as on the front of the body treatment by the spray is difficult, as turning the patient to spray the back may easily dislodge the thin, newly-formed crust on the front of the body. A compress soaked in tannic acid solution is generally employed for those parts which cannot be adequately reached by the spray. In order to prevent rapid decomposition of the tannic acid in solution, small quantities of mercuric chloride are added. Mitchiner recommends a solution of the following composition:

Tannic acid compresses

Tannic acid – – – – 17½ grains
Mercuric chloride – – – ½ grain
Distilled water – – – to 2 fl. ounces

This constitutes a 2 per cent solution of tannic acid. The preliminary treatment is the same as in the spraying method. Meticulous care is expended in obtaining complete cleanliness under morphine or general anaesthesia, and then the compress is applied. This consists of six or more layers of gauze, steeped in the warm solution and not wrung out, and bandaged firmly over the burnt area. The compress is then further soaked *in situ* and is left on the patient without disturbance for a fortnight to three weeks. It is a little more uncomfortable for the patient than the spraying method, and is suitable only when spraying is not practicable. One drawback of the method is that the solution causes rotting of bed-linen, and consequently a mackintosh should be kept between the patient and the bed-clothes.

Recently, stronger solutions of tannic acid have been used. It seems quite safe to apply 10 to 20 per cent solutions, indeed they produce the crust of coagulated protein more rapidly and with less disturbance to the patient. But the advantages are to some extent offset by the fact that the crust is usually thin and becomes detached too easily.

Reinforced tannic acid crust

These methods of treatment are satisfactory in hospital, but the practitioner often has to deal with burns of less extent, which, though very painful and disabling, scarcely justify the removal of the patient from home. For these smaller burns a new technique, that of 'reinforced tannic acid crust', has been evolved. The crust is reinforced by painting the surface with collodion; this method of treatment was introduced a few years ago by Hunt and Scott. They recognized within the category of lesser burns three types of lesion: (1) the recent clean burn in adults, (2) the same lesions in children and (3) the lesion to which greasy dressings have been applied, perhaps for a few days, with resulting onset of infection.

Procedure for adults

For adults with recent and clean burns, the treatment recommended, after cutting off all dead skin and laying bare all blistered surfaces with a sharp pair of scissors, is to paint with a soft camel's-hair brush a 5 per cent solution of tannic acid in water (20 grains of powdered tannic acid, a level teaspoonful, to an ounce of warm water, makes a 5 per cent solution). When the surface has been thoroughly painted, a single layer of gauze is laid over the burnt area so as to overlap it on all sides, and a further coat of tannic acid is put on over this. Similarly three or more layers of gauze are laid over and impregnated with the solution. A firm bandage over some wool controls all these layers.

On the next day the wound is inspected and all loose layers of gauze are removed. The deepest layer is then usually adherent to the burnt surface and should not be disturbed. A procedure exactly similar to that of the first day is carried out.

For the next three or four days this is repeated, until by the fifth or sixth day the area is covered by a firm layer of gauze, strongly adherent to the crust on the burn. This whole area is then painted over daily for a few more days with a 2·5 per cent solution of tannic acid, and 2·5 per cent solution of collodion in ether. This gives the encrusted gauze such stability that no dressing is required and the patient can follow his usual vocation. On about the sixteenth day the crust loosens, and should be allowed to be cast off spontaneously.

If the crust becomes moist and tends to separate at the edges too early, it is always the result of slight sepsis; small spirit dressings applied on the affected area, followed by repeated painting with the tannic acid solution and collodion solution in ether, will prevent spreading of the infection.

The application of the watery solution of tannic acid is painless, and no anaesthetic, local or general, is required. Painting of the crust with tannic acid solution and collodion in ether is painful when there are gaps in the crust, and the patient should be warned to expect a little pain.

Procedure for children

When a child has been similarly burnt the treatment would be the same if it were not for the difficulty of treating a burn in a frightened child who will not allow anyone to touch the part. Moreover, children cannot be prevented from scratching and picking at any crust or spot on the body, and this interferes materially with healing; a very strong crust must therefore be employed. When the child is very nervous, general anaesthesia with ethyl chloride should be used for the first dressings. In less frightened children an injection of 4 per cent procaine hydrochloride solution (novocain) into the contents of each blister, together with injection of 2 per cent or 4 per cent procaine hydrochloride solution into the skin all round the burnt area should be sufficient. Gas or a little open ether is an alternative. Anaesthesia of the part is necessary, because to obtain a really strong crust the surface must be painted with the 2·5 per cent solution of tannic acid and 2·5 per cent collodion in ether solution directly after thorough cleaning. Gauze is then laid over this and is again painted with the solution. This process is repeated until the burn is covered with a really strong layer of gauze crust and collodion. If next day the more superficial layers are loose, they are removed, and fresh layers are stuck on to the fixed ones with collodion. Repetition of this is rarely necessary on the third day.

By this method a strong crust is obtained in the minimum time, and with the least possible number of inspections of the wound, an operation always dreaded and often actively resented by a nervous child.

Removal of greasy ointments

When a patient has been treated for some days with an ointment or oily application (e.g. Carron oil) infection has usually occurred. In this event the first step in treatment is to render the area insensitive by local anaesthesia or by morphine and gas and oxygen. The blisters are then cut away, and the surface thoroughly cleaned of debris and grease with ether, followed by alcohol. This would be impossible without the use of anaesthesia. A 2·5 per cent solution of tannic acid in ether is painted on the surface, and then layers of gauze, one by one, are painted on to the area, and stuck down with more of the solution. Two days later the wound is again dressed, and all the gauze is removed; if the deepest layers are adherent, they should be left. The same solution is again painted on and the gauze re-applied, layer by layer. The patient should be warned that this repainting will certainly cause pain in places where the crust is defective.

These layers of gauze are left intact, and the whole application is painted over daily until it looks quite dry. A spirit dressing is useful if any wet spots appear. The whole application may be reinforced if necessary with collodion in ether on the sixth day. The crust usually separates at the end of a fortnight.

These methods for the treatment of ambulant patients are specially

Summary of treatment

valuable in general practice, but to obtain the best results, the following should be borne in mind:

(1) A first-aid dressing should never be greasy, but preferably of 5 per cent tannic acid in water. Watery solutions of tannic acid decompose readily, but decomposition can be prevented by the addition of mercuric chloride (see p. 725). A better way of preserving the tannic acid is to keep it dry in packets of 20 grains. In this state it does not decompose, and need only be added to 2 ounces of warm water to make up the correct solution.

(2) Except for first-aid treatment no burn, however trivial, should be treated until it has been thoroughly cleansed. Pain in the burnt area should not be allowed to prevent this and a local or general anaesthetic should be given if necessary.

(3) Careful daily attention to the crust is necessary for the first week.

Picric acid treatment

Tannic acid is not the only coagulating fluid employed. It was preceded by the use of a 2 per cent solution of picric acid in water; picric acid is an efficient protein coagulant and is cheap. In solution it does not decompose and its use on burnt areas is painless. It is, however, not so effective as tannic acid, but is still widely used.

(2)—Fourth and Fifth Degree Burns

In these latter cases, the skin has been completely destroyed, and masses of dead tissues must be discarded by the patient's tissues before healing can occur. There is therefore no indication to use any surface-coagulating fluid and treatment usually consists in daily dressing of the area by acriflavine emulsion B.P.C. Acriflavine is a powerful and harmless antiseptic, and the liquid paraffin in the emulsion prevents the dressings from adhering.

If the burns are extensive and infection is considerable, much improvement, both local and general, may be obtained by immersing the burnt area continually in a warm saline bath. Sometimes this necessitates the complete immersion of the body of the patient; but with skilled attention and perseverance the patient can be kept in such a bath for a week or more. After a few days the hectic temperature is reduced to normal and the sepsis will be found to have disappeared almost entirely.

Many severe burns heal rapidly if they are covered with packs of gauze impregnated with soft paraffin and a firm bandage is applied over them. This dressing is allowed to remain in place until it becomes soaked with pus and offensive.

When all the dead tissue has been thrown off and the wound is covered with healthy granulation tissue, skin grafts will hasten recovery. These grafts may be thin strips of epithelium (Thirsch grafts), or may be small islets of skin snipped off by pulling on a hair and snicking off the skin at its base; these are known as 'pinch' grafts.

Deformity must be prevented by immobilization of the burnt area in a splint; prevention of deformity in the face and neck is difficult and provides a field for skilled plastic surgery.

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BURSITIS

See CORNS AND BUNIONS; *and* FIBROSITIS

BYSSINOSIS

See PNEUMOCONIOSIS

CAESAREAN SECTION

See LABOUR

CAISSON DISEASE

(COMPRESSED-AIR ILLNESS)

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I.—CAISSON DISEASE

210.] With the exception of rare accidents, caisson disease, better called compressed-air illness, is only encountered in divers and caisson workers. Caissons are large cylinders or chambers with an air-lock at one end and open at the other. They are used for sinking mines or boring tunnels in moist or soft ground and for laying the foundations of bridges, piers, and other structures under water. Water and mud are prevented from entering the open end of the caisson by pumping in air under considerable pressure. Men who work in caissons, or in the ordinary rubber diving dress, are surrounded by, and breathe, compressed air which may be at several times the normal atmospheric pressure.

Exposure to compressed air is not in itself dangerous; it has no appreciable physiological effects, except change in the tone of voice, inability to whisper or whistle, and pain in the ear if the Eustachian tubes are not patent. The latter symptom is caused by the pressure being greater outside than inside the tympanum.

The risk of developing caisson disease only arises after the return to normal atmospheric pressure; in technical language, on decompression of the subject.

1.–AETIOLOGY

Mechanism of causation

It is now definitely established that the cause of compressed-air illness is the formation of bubbles of nitrogen in the blood and tissues as the result of too rapid decompression. One of the prettiest demonstrations of the mechanism of the causation and cure of compressed-air illness was originally due to Leonard Hill (1912) and his co-workers. They devised an apparatus in which a frog could be exposed to various atmospheric pressures at the same time as the capillary circulation in the web of the frog's foot could be watched under the microscope. In Hill's (1912) own words: 'On suddenly decompressing after a long exposure we had the keen pleasure of seeing the bubbles appear in the capillaries, grow in size and stop the circulation, to shrink and disappear again on putting up the pressure'.

Solution of gases in blood

In order to understand the cause and symptomatology of caisson disease the following physical phenomena must be borne in mind: (1) All gases dissolve in blood or other fluids in direct proportion to their pressure. Thus the blood and tissues of a man under 60 lb. gauge pressure (75 lb. absolute pressure) or 120 feet below the surface of the sea, is potentially capable of taking up five times as much nitrogen as when at normal atmospheric pressure at sea-level (roughly 15 lb. per sq. inch). Therefore when a diver ascends too rapidly his blood and tissues become supersaturated with nitrogen and bubbles are released, just as they are in the previously still fluid in a bottle of soda-water when the pressure is relieved by drawing the cork. (2) The gas is pure nitrogen because the tissues use up all the oxygen, and the accumulation of carbon dioxide is prevented by respiration. (3) The blood in its passage through the lungs becomes almost immediately saturated, but the tissues in turn take up the nitrogen only very slowly from the blood. It was formerly thought that the tissues approached saturation within three hours, but more recent experiments on goats have shown that the liver, brain, and bone marrow are only about 50 per cent saturated after three to five hours' exposure. Moreover, depending on their blood-supply, different parts of the body take up nitrogen at different rates. (4) Nitrogen is about five times as soluble in fats as in other tissues; therefore an animal containing 25 per cent of fat should be able to dissolve about twice as much nitrogen as one without any fat.

Variable factors

To summarize, the risk of developing compressed-air illness increases with (*a*) the magnitude of the pressure, (*b*) the time of exposure to the pressure, (*c*) the rapidity of decompression, and (*d*) the obesity of the subject.

2.–CLINICAL PICTURE

The dangers of compressed-air illness and its prevention by slow decompression are so generally realized that the severer types of caisson disease are now rare.

The onset of the symptoms is usually delayed fifteen minutes to an hour after decompression, because it takes time for the tissues to liberate an effective quantity of gas.

Air-embolism

The variety and severity of the illness depend on the volume of gas set free and the site of its liberation. The symptoms may sometimes be caused by direct injury to the tissues at the site where the gas is set free, but from the suddenness of their onset they are probably more often caused by embolism, bubbles of nitrogen being carried from other parts to lodge in the arterioles of the central nervous system or unyielding structures such as bone, ligaments, tendons and fasciae. The gas bubbles in these latter situations cause the acute pains known as 'bends' and 'screws' which are the mildest, most transitory, and commonest type of compressed-air illness. 'Bends' usually clear up within twenty-four hours, even without treatment. The most serious types of caisson disease are produced by embolism of the central nervous system. Nervous signs of all degrees of severity and character have been described, from slight vertigo and muscular weakness to paralyses of all kinds, coma, and death. Abdominal pains, especially if they are of the 'girdle' type, signify embolism of the spinal cord, as does also the common occurrence of paralysis of the bladder with retention of urine. Usually patients with these symptoms recover completely in a week or so, but a certain number develop a spinal myelitis from which the patient may die, or ultimately recover with more or less residual paralysis. In these cases there is a tendency to great wasting and trophic disturbance leading to the formation of those deep extensive bed-sores which were formerly so characteristic of severe paraplegia however caused. These patients after lingering for weeks or months may die of an ascending pyelitis or as a result of septic absorption from their trophic ulcers.

Embolism of nervous system

Mottling

Occasionally embolism of the pulmonary arterioles makes dyspnoea and discomfort in the chest the predominant signs. Gas in the skin and subcutaneous tissues may cause mottling, itching, and skin crepitations. Mottling is considered a grave sign as it indicates the release of a large volume of gas.

3.–DIAGNOSIS

The diagnosis of caisson disease merely depends on eliciting the fact that a patient with any of the symptoms described above has been in compressed air within an hour or two of the onset of his illness.

4.—PREVENTION

Caisson disease is now almost wholly prevented by decompressing the diver or caisson worker at a rate which is slow enough to allow the nitrogen to diffuse out of the blood and tissues without forming gas bubbles. The time required is dependent on the pressure at which the subject was working and the time he was exposed to it. The pressure may be reduced at a uniform rate or in stages. Numerous animal experiments have failed to give any significant evidence as to which method, the times being equal, is the safest. For divers the 'stage' method is definitely the more convenient, and the Admiralty decompression tables for use with this method were worked out more than twenty-five years ago by Boycott, Haldane and Damant (1907). These tables are based on the following principles:

Principles of 'stage' decompression

(1) That the saturation of the whole body with nitrogen at any pressure is not approached in less than about three hours. But, as mentioned above, it is probable that it takes much longer than three hours to approach saturation, an inference which is borne out by the observation that 'bends' or other symptoms occur more frequently after a five or six hours' dive than after one lasting only three hours.

(2) That bubbles never form in the blood after pressures below 20 lb per sq. inch in excess of normal atmospheric pressure. Therefore divers who have worked less than three hours at less than seven fathoms may ascend to the surface at once (7 fathoms = 42 feet, producing a pressure of 18·5 lb. per sq. inch).

(3) That it is always safe to diminish at once the pressure by rather more than half without danger of caisson disease.

(4) That the nitrogen escapes more rapidly at first, hence the time spent in the later stages of decompression must be made progressively longer.

Practice of 'stage' decompression

The following examples from the Admiralty Tables illustrate the use of these principles in practice. A man who has been working at 11 fathoms (about 30 lb. gauge pressure) for only 15 minutes can come up at once, for he has not had time to absorb a dangerous quantity of nitrogen. Should he have been exposed to this pressure for more than two hours he can safely ascend at once to within 20 feet of the surface, where he must wait for 10 minutes before ascending another 10 feet, at which stage he has to remain 20 minutes before 'breaking surface'—the whole ascent occupying about 32 minutes. A diver who has been working at 200 feet for 1 hour and 50 minutes can ascend at once to 80 feet. He then ascends 10 feet at a time, waiting a longer time at the later stages, and takes in all 238 minutes to reach the surface—4 hours' decompression for about two hours spent on the bottom! To obviate the disproportionate time which has to be spent in decompression in deep diving, decompression in an atmosphere of pure oxygen is now employed. By this means the difference between the pressure of nitrogen

Decompression in pure oxygen

in the blood and the alveolar air is greatly increased, and the nitrogen is thus 'extracted' more rapidly. The procedure consists in lowering to meet the diver the special decompression chamber invented by Sir Robert Davis. This contains pure oxygen, in which the diver is safely decompressed in two-fifths of the time which would have to be occupied in air decompression. In this way it is now practical for a diver to work at a depth of 300 feet in an ordinary rubber dress. It is unlikely that it would be safe to proceed much deeper, because in experimental animals symptoms of poisoning occur as the pressure approaches three atmospheres of pure oxygen. Men have been exposed to two atmospheres of pure oxygen for over an hour and only felt the better for it, and the partial pressure of oxygen in the air of a diver's helmet during a 300-foot dive is equivalent to two atmospheres of pure oxygen. Incidentally, oxygen poisoning is more truly carbon dioxide poisoning, because when there is much oxygen present in the blood the oxyhaemoglobin remains unreduced and carbon dioxide accumulates to a dangerous extent.

Decompression in helium and oxygen

In passing it is noteworthy that artificial atmospheres of helium and oxygen have been tried in America for deep diving and decompression. In these atmospheres the time required for decompression should be reduced in theory to less than that required in oxygen, because helium is less soluble in blood than nitrogen, and, in consequence of its low density, has a much higher rate of diffusion.

5.–TREATMENT

Recompression chamber

The treatment of compressed-air illness is immediate recompression. Recompression is preferably done in a chamber especially designed for the purpose into which air can be pumped rapidly up to any required pressure, and in which the rate of decompression is under exact control. The sooner the patient is recompressed the more rapid and permanent is the relief of his symptoms. The rare cases in which recompression fails are those in which the nitrogen bubbles have had time to do lasting injury before they were diminished in size or forced back again into solution by the re-application of high atmospheric pressure. The method usually adopted is to recompress the patient rapidly to that pressure in which he had been working, and then start decompression according to the rates laid down in the Admiralty Tables. Alternatively Keays (quoted by Hill, 1912) raised the pressure to that at which the patient had been working and took twice as many minutes as the pounds pressure to which the victim had been exposed, to reduce the pressure to normal. Damant (1926), as a result of his experience of minor degrees of caisson illness, only raised the pressure up to the point where the symptoms were relieved, and then decompressed according to the following rules. Between 45 and 30 lb. per sq. inch the pressure should drop 1 lb. in 3 minutes, between 30 and 15, 1 lb. every 5 minutes, and from 15 lb. to zero 8 minutes should be allowed per lb. drop in pressure.

In a few cases symptoms recur after treatment, and one or more recompressions may be required to effect a permanent cure.

Re-descent followed by regulated ascent

Cases of compressed-air illness have become so rare among divers since the rules for safe ascent were instituted that it is not deemed necessary to supply special decompression chambers to H.M. ships. In the case of compressed-air illness arising in a diver when no decompression chamber is at hand, he should be immediately lowered to the bottom again, even should he be unconscious, and hauled up at the routine rate for the depth and the time he had been submerged. If possible, another diver should descend with him, but no time must be wasted in trying to obtain a second diver.

Oxygen

Massage

Relief of pain

In the absence of facilities for recompression the treatment consists in giving oxygen, which not only accelerates the diffusion of nitrogen out of the lungs but keeps life going while the circulation is partially obstructed by gas bubbles. Massage and exercise, by increasing the rate of the circulation, enable the blood to wash the nitrogen out of the tissues in a correspondingly shorter time. Morphine may be given to relieve the pain so constantly present in all types of caisson disease. No treatment, however, can effectively take the place of immediate recompression, but if recompression is delayed for six hours after the onset of symptoms, it is probably no better than medical treatment.

II.—RUPTURE OF THE LUNGS

211.] In conclusion attention must be drawn to a form of compressed-air casualty which is caused by a mechanism entirely different from that causing caisson disease.

Aetiology and pathogeny

In the United States some cases of sudden death have been reported among men who were practising escape from submarines. The victims of these disasters had generally only been exposed for a few minutes to the pressure of about 30 feet of water, but they all had come up suddenly to the surfaçe and collapsed and died within a few minutes. The cause of these disasters is uncertain, but, because bubbles of gas were found in the blood-vessels and under the pleura, it had been suggested that the victims of these disasters were cases of 'acute' caisson disease. The time and depth of exposure made this hypothesis untenable. The presence of the bubbles was probably due to the suddenness of the ascent having allowed the intrapulmonary pressure to rise to such an extent that the alveoli of the lung were ruptured, and air was forced into the pulmonary veins, and thence to the left heart with resulting acute air-embolism and sudden death. Experiments on dogs have shown that it is possible to force air into the circulation by suddenly increasing the intrapulmonary pressure.

Prevention Such accidents can be prevented, if in practising submarine escape the men come up relatively slowly on a rope, pausing at intervals for a few seconds and breathing deeply in order to allow the pressure in their lungs and escape apparatus to become equal to the hydrostatic pressure of the water which surrounds them.

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CALABAR SWELLING

See Filariasis

CALCULI

See Bladder Diseases, p. 385; Gall-Bladder and Bile-Ducts; *and* Kidney, Surgical Diseases

CANCER

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Reference may also be made to articles on individual organs (*e.g. breast*) *and to the following title:*

TUMOURS

212.] Under the term 'cancer' are included all forms of malignant new growths whether of epithelial or connective-tissue origin. A definition of cancer must necessarily be a description because of the present uncertainty concerning aetiology. Ewing defined a tumour as 'an autonomous new growth of tissue'. In this simple definition the autonomous character of new growths is used as the sole constant difference between malignant and normal growth. Other writers extend the descriptiveness in their definitions. It is usual to speak of tumours as new growths of tissue which apparently arise spontaneously, which are atypical in structure, do not serve any purpose in the body and reach no termination in their growth.

1.–INCIDENCE

Distribution of cancer

Cancer occurs in all races of mankind, civilized and uncivilized. It has been found, whenever properly looked for, in all vertebrate animals, wild and domesticated, carnivorous and herbivorous. Cancer shows the same features—biological, clinical and microscopical—in man and the lower animals.

Statistics of chief sites of cancer

In the Registrar-General's Statistical Review for the year 1934 the total number of deaths from cancer in England and Wales during 1934 is reported as 62,263. Of these deaths no fewer than 34,358 were due to cancer of the 'digestive organs and peritoneum'; 6,687 were due to cancer of the breast in women, 4,451 to cancer of the uterus and 3,431 to cancer of the male genito-urinary organs. These figures show that cancer is one of the commonest diseases of mankind and indicate the chief sites of the disease.

The question of increased incidence

When the crude death-rates over a period of years are examined it appears that cancer is increasing in frequency at an alarming rate. In 1924 the number of males at all ages to a million living who died of cancer was 1,246; in each subsequent year this figure has risen until in 1934 it has reached 1,534. An examination of the sites of the disease shows that for cancer of the buccal cavity and pharynx the crude death-rate for males for 1924 was 152, for 1934, 155 and for the intervening years a figure fluctuating between 145 and 165; the figures for the uterus show that between 1924 and 1934 there has been a slight reduction; for the skin there has not been any change during the same period. Thus in the sites where cancer is most easily recognized the death returns do not indicate any increase in the frequency of the disease. It is in the figures for cancer of the internal organs, where it is admittedly more difficult to diagnose, that there is an apparent large increase. For cancer of the digestive organs and peritoneum the figures for males for 1924 are 791, for 1934, 927; for the respiratory organs 81 and 168. The apparent large increase in cancer is thus confined to the sites where diagnosis is difficult and the inference may be drawn that the increase is to be explained partly by the improvements in diagnostic methods and the greater interest in cancer in recent years.

2.–PATHOLOGY AND AETIOLOGY

Pathology

Cancer is a local disease. A group of normal cells, or possibly sometimes a single cell, acquires malignant properties; the cells grow and multiply independently of the needs of the body as a whole and eventually form an abnormal swelling—a tumour. The whole of the new growth is derived by the process of cell-division from the original cells which became, under known or obscure conditions, malignant. The growth of the tumour is at first expansive; contiguous normal tissues are pushed before it. This process of growth is observed most clearly in the less malignant tumours, such as uterine myomas. In the more malignant tumours growth becomes infiltrative at a comparatively early stage; groups of malignant cells penetrate into adjacent tissues and these are often destroyed. Growth by infiltration of surrounding tissues may continue until lymphatic channels become permeated by malignant cells which may be found at great distances beyond the original focus. In this way neighbouring lymphatic glands become invaded. The process continues until malignant cells reach the internal organs where they may grow to form metastases. In destructive tumours, especially the sarcomas, blood-vessels may become eroded and tumour cells enter the circulating blood by which they are carried to distant parts.

Changes occurring in malignant cells

Tumour cells normally show some change from the form characteristic of their cell of origin; there is a variation in size, the nucleus stains more deeply with haematoxylin and the mitotic figures are sometimes atypical. But in many tumours, especially the carcinomas, the orderly arrangement of cells is not greatly disturbed and the individual malignant cells are but slightly changed. It is not possible to recognize a tumour cell when it is separated from other tumour and normal cells; diagnosis of tumours depend upon the recognition of tumour cells in mass and the relation of the mass to normal tissues.

Classification

Tumours are classified according to their histological structrue into the following groups: (1) Tumours derived from connective tissues: fibroma, chondroma, osteoma, sarcoma, lipoma. (2) Tumours derived from epithelial tissues: papilloma, adenoma, epithelioma, carcinoma. (3) Tumours derived from muscle tissues: leiomyoma, rhabdomyoma. (4) Tumours derived from endothelium: endothelioma. (5) Tumours derived from parts of the nervous system: neuroma, glioma, neuroma ganglionare, neuro-epithelioma. (6) Complex tissue tumours: simple mixed tumours, teratomas, embryomas. All such classifications are descriptive and difficulties of diagnosis are often solved by the invention of new terms. All neoplasms are new growths, arising *de novo* in each affected individual; nomenclature is a mere descriptive convenience and should be flexible.

Aetiology

Our knowledge of the aetiology of cancer in man is derived mainly from clinical observation and from the study of mortality statistics. The most striking feature of cancer is its age-incidence. In the earlier age-groups it is rare; it appears first in middle age and increases rapidly from then onwards with advancing age. The second feature bearing on aetiology is the frequent association of cancer with some form of chronic irritation. The experimental study of the artificial genesis of cancer under the influence of carcinogenic agents has provided a rational explanation of the age-incidence of the disease, as will be shown presently.

Chronic irritation

In 1775 Percival Pott observed that chimney-sweeps are prone to epithelioma in areas of the skin which are subjected to long-continued irritation by soot and the tarry products of the combustion of coal. The greater frequency of cancer of the skin in the poor, who from negligence or lack of means do not obey ordinary rules of cleanliness, compared with the educated prosperous classes, is a well-founded clinical and social observation. This liability to cutaneous epithelioma is accentuated among men who are exposed in their daily avocations to the action of tar and pitch, lubricating oils, and paraffin. The association of skin cancer with chronic syphilitic or tuberculous lesions, with the scars of burns and with X-ray dermatitis is known to all experienced clinicians. An example of cancer of the skin following long-continued irritation from heat is found in the Kangri cancer of natives of Kashmir (see Bashford). Cancer of the tongue and mouth is associated with syphilis, decayed teeth or ill-fitting dentures; leukoplakia is rightly described as a precancerous condition of the tongue. Other well-known examples of cancer following chronic irritation are cancer of the bladder subsequent to bilharzia infection, cystitis or lithiasis; cancer at the ureteral orifices among aniline workers; duct carcinoma following cystic mastitis; and cancer of the liver associated with the presence of parasitic worms. As this brief list of types of cancer which are caused by chronic irritation shows, the source of the irritation may be chemical—tar or soot; physical—heat, X-rays; or living—parasitic worms.

Experimentally produced cancer

Cancers have been produced experimentally by similar agents. Clunet (1910) produced sarcoma in a rat by repeated application of X-rays. Fibiger (1913) induced cancer of the stomach in rats by feeding the animals with cockroaches which carried the ova of a round worm, the *Gongylonema neoplasticum*; this nematode lives in infested rats in the epithelium of the fundus of the stomach, and sets up inflammatory changes which are followed by papillomatous growths and in some instances by cancer. Fibiger's experiments have not yet been confirmed.

Tar tumours

Yamagiwa and Itchikawa (1916) painted the skin of rabbits with coal tar during a period of 1 to 3 years; papillomas of the skin developed at the site where tar was applied and after variable periods squamous-celled carcinoma followed. Mice are more susceptible than rabbits to the carcinogenic action of tar, and it is with mice that the greater part of the work on experimental carcinogenesis has been carried out. It has been found that the period of cancer induction in mice is from 3 to 8 months, in rabbits 1 to 3 years, in rats—sarcomas, by injection of tar—1 to 2 years, and in fowls—sarcomas—1 to 2 years. In all species of animals the application of tar must be continued for a long time; in man under industrial conditions 10 to 30 years of daily exposure are usually necessary before epitheliomas appear. These facts, which have been abundantly confirmed, show that the probable explanation of the appearance of cancer in the later decades of life lies in the diminishing resistance of the tissues to malignant transformation under the ordinary physical insults of life and not, as was formerly supposed, in a tissue or cell instability which was supposed to occur in the later periods of life and which was described in the term 'ageing of tissues'.

Kennaway and Cook have prepared a series of pure chemical compounds which when applied to the skin cause epitheliomas and which when injected subcutaneously cause sarcomas. These carcinogenic compounds have a phenanthrene group of benzene rings as a common chemical characteristic; they have a high melting point and are soluble in fat solvents, such as benzene and chloroform. The three most active compounds of the group are 1 : 2 : 5 : 6–dibenzanthracene, 1 : 2–benzpyrene and methylcholanthrene.

Browning (1933) proved that a water-soluble styryl compound induces sarcoma formation when injected under the skin, and Yoshida (1932) claims that when *o*-amido-azotoluol is fed to rats malignant tumours of the liver are caused.

This brief summary of experiments with chemical compounds indicates that a number of pure substances, dissimilar in chemical characters, are carcinogenic. It has been an aim of research to find carcinogenic agents among chemical substances normally present in the body, or alternatively to discover whether substances which are proved to be carcinogenic may be derived by simple chemical transformations from normal body constituents. Methylcholanthrene is prepared in the laboratory from bile acids and it is thought that the chemical change occurring in the reaction is possible in the body. Dibenzanthracene has a structure very like that of the hormone oestrin and recently it has been proved by Lacassagne (1932) that oestrin itself causes cancer of the breast in mice which are especially susceptible to cancer. This important observation has been confirmed by Burrows (1935) and by Cramer and Horning. The oestrin is dissolved in chloroform or benzene and the solution is painted on the skin of male mice of a cancerous stock. The oestrin passes through the skin into the body, causes enlargement and cystic degeneration of the mamma (Schimmelbusch's disease) and finally cancer. The important difference between the carcinogenic action of oestrin and of tar or the pure chemical substances, such as dibenzanthracene, is that whereas tar and the chemicals prepared in the laboratory act at the site where they are applied, oestrin acts specifically on the mamma, remote from the site of application.

Carcinogenic action of oestrin in animals

Clinical observations and experimental investigations have proved that many malignant new growths owe their origin to the effects of long-continued irritation or to the obscure action of chemical compounds which cannot properly be described as irritants. It is possible that future research may reveal the existence of other carcinogenic substances with local specific action and thus offer a satisfactory explanation for the local occurrence of most, if not all, cancers. But all this effort has failed to provide an explanation of the essential property of tumours—namely, autonomous growth. Carcinogenic agents are best described as predisposing causes; a satisfactory explanation of cancer must not only reveal the predisposing causes, but must also provide an explanation of the independent proliferative power of malignant cells.

Propagation of tumours

A tumour induced by a carcinogenic agent, whether the agent be a living parasite, a pure chemical compound or physical radiations, can be propagated indefinitely in series of animals of the same species as that in which the original tumour was produced; in all these transplantations the carcinogenic agent plays no part. The agent causes normal cells to become malignant and plays no further part in the evolution of the tumour; the malignant change is irreversible. Experimental research is still seeking for an explanation of the malignant properties of the cancer cell. Many solutions of the problem have been

The virus theory

put forward, but none has yet received general assent. The most satisfactory is that which explains malignant proliferation as a response by the cell to the presence of an intracellular infective virus. The evidence for this view is far from complete, but its strength lies in the fact that for tumours of fowls it has been proved to be the correct view. It was found by Rous (1911) that tumours of fowls are transmissible by means of cell-free extracts. The tumour produced by such an extract is always the same macroscopically, microscopically, and clinically as the tumour from which the extract was prepared. For example, a filtrate of a spindle-celled sarcoma always gives rise to a spindle-celled sarcoma, and a filtrate of an osteo-chondro-sarcoma always gives rise to an osteo-chondro-sarcoma. The most minute characteristics of a tumour are reproduced in tumours induced by injecting cell-free extracts. The causative agent which passes through the filter-candle possesses a specificity of the same kind as that of the tumour cell from which it is derived. The agent is particulate, has a constant size of approximately 0·1 micron, is an antigen which evokes formation of antibody in the fowl and in other species of animals—rabbit, goat and horse. The antibody to the agent derived from one tumour of a fowl neutralizes the agents obtained from all other fowl tumours. The knowledge of these agents gained during the past ten years is consistent with the view that they are viruses; immunological experiments have proved that the viruses are closely related to one another. Although tumours of fowls are caused by viruses, they are similar to human tumours in being non-contagious and curable by early removal, in exhibiting autonomous growth and in spreading in the body by cell metastases.

Tumours of mammals, with the exception of a papilloma of the cotton-tail rabbit (Shope, 1933), have not been propagated with cell-free extracts.

3.–CLINICAL PICTURE

Signs and symptoms of cancer

Only a few of the signs and symptoms of cancer can be described here, as this article deals with cancer as a whole. Cancer is painless and symptomless in its onset. This is of very great practical importance because cancer in its early stages is curable but owing to this painlessness is not easily recognized until late symptoms develop. A malignant tumour of itself does not cause any symptoms unless (1) it becomes so large that it causes pain by stretching or invading sensitive structures, or (2) it ulcerates and becomes infected with micro-organisms in which case the pain of inflammation occurs, or (3) it involves in its growth a tubular structure such as the intestine or common bile-duct.

Cancer in superficial situations, as in the skin, the subcutaneous tissues, the breast or the testicles, is usually discovered by the patient, who feels a painless lump. With cancer in deeper situations, as in the brain, the oesophagus, bronchus, stomach, rectum or uterus, the patient first becomes aware of the condition either from pain or some symptom such as indigestion, vomiting, cough or haemorrhage, characteristic of involvement of the organ by a new growth.

Physical signs

There is no physical sign of cancer which always puts the diagnosis beyond doubt. The two main signs which when present together indicate strongly the presence of a malignant neoplasm are hardness and fixity. But both sarcomas and carcinomas may be soft in consistency. This is especially true of the rapidly growing sarcomas and of some carcinomas to which the terms encephaloid or medullary are then applied.

Fixity of growth

Fixity of the tumour is more important than consistency in that it points to infiltration of surrounding normal tissues by the new growth; a superficial tumour becomes attached to underlying structures and a deeply-seated tumour, such as one arising from bone, becomes attached to overlying tissue.

Cachexia

In the advanced stage of many cancers cachexia is present. This condition was more emphasized formerly than it is now, possibly because tumours are now seldom permitted to advance to a late stage before treatment is begun. Undue importance should not be attached to cachexia as a physical sign of cancer. The explanation of cachexia is obscure, but it is probably to be found in secondary infections of tumours and in the involvement of important organs of nutrition, such as the liver, leading to malnutrition. Some authorities believe in the existence of a cancer toxin which is supposed to affect the well-being of a patient, but a toxin has not been demonstrated. It is believed by many authors that cachexia is a consequence of the absorption of dead and dying cancer cells, but against this belief may be put the fact that very large amounts of cancer tissue may be injected into animals without producing any sign of cachexia.

4.–DIAGNOSIS

Histology

An accurate diagnosis of cancer can often be made by determining the physical signs already described. But in many cases it is necessary to remove a piece of the tumour for section to establish the diagnosis. Indeed, a section must always be obtained before a diagnosis is proven. Although in most cases a section provides conclusive evidence, in some tumours, for example, fibrosarcomas, doubt may still be present after a study of the histology. Frozen sections are often made at the time of an operation as a help and guide to the surgeon, but often in those cases in which there is doubt after naked-eye examination of the tumour, there is also doubt after examination of the frozen section. It is probably for this reason that frozen sections are not used more frequently. Considerable care must be taken when removing a piece of a tumour for section; a piece of adequate size and from the right part of the tumour must be removed. Tissue taken from the surface of a tumour may be unreliable in deciding between an innocent and malignant growth. For example, in the bladder, there may be no real evidence of a carcinoma in a piece removed from the surface of a growth, although examination of the base may show definite infiltration by malignant cells.

Secondary deposits

The presence of definite secondary deposits confirms a diagnosis of cancer, but it must always be borne in mind that the enlargement of lymph nodes may be due to recent septic lymphadenitis or even that the enlargement has existed for years and is altogether independent of the neoplasm. It is advisable to make the diagnosis from examination of the primary growth alone, and let the condition of the lymph nodes help in determining the prognosis.

5.–TREATMENT

It has been proved that cancer begins as a local disease and is confined to the cells primarily affected and to their lineal descendants. Cancer is not a constitutional malady, nor is there a 'cancer dyscrasia'. The ideal of treatment is the complete removal of the primary tumour at the earliest stage of the disease before dissemination has taken place. It cannot be too strongly emphasized that there is at present no method of curing cancer other than surgical removal or treatment with radiations.

In spite of the immense efforts of surgeons in every civilized country to find methods of treatment alternative and preferable to surgical removal it is still true that except for certain tumours excision of a growth by surgery is the best form of treatment. The advantage which radio-therapy has over surgery is that the patient is saved the shock and mutilation of an operation and therefore in those situations where radium and X-rays give a result as good as excision, they should be preferred, but this can be said to be true of comparatively few parts.

Radical removal

In excising the tumour a sharp scalpel or a diathermy cutting-electrode may be used. The advantages of the latter instrument are twofold: first, there is less bleeding when the tissues are cut because coagulation occurs as the small vessels are divided; and secondly, a certain number of cancer cells are probably destroyed by the current as it approaches infected areas. Its disadvantages are that the instrument is expensive, and that unless the surgeon has a proper knowledge of the method of its use great harm may be done to the tissues with consequent delayed healing.

A tumour must be excised with an adequate portion of healthy surrounding tissue including lymphatic vessels and lymph nodes draining the part. In spite of some dissension in the past it is now considered wisest to remove lymphatic glands in all cases even if they are not palpably enlarged.

A growth may be inoperable for the following reasons: (1) It is too firmly fixed to surrounding structures which cannot be sacrificed. (2) Metastases are either too numerous, too distant or too adherent. (3) The patient's general condition does not permit a major surgical operation.

Radium therapy

In 1898 Madame Curie discovered the element radium, but it is only in the last twenty years, after much clinical trial, that it has become a powerful and really useful therapeutic weapon. The element radium or its emanation, radon, a heavy inert gas, may be used. The latter has all the radio-active and healing properties of radium but has the disadvantage that it 'decays', losing half its strength in three to eight days, and in nine days having but a fifth of its original power. For practical purposes it may be said that radium loses nothing as it gives off radon; thus radon is comparatively cheap and is therefore more readily available for general use than radium itself. Further, since radon decays and after a month is practically without any action, radon seeds can if necessary be left permanently in the tissues, a thing impossible with radium owing to its continued action and costliness.

The gamma rays of radium are those used in the treatment of cancer. The alpha and beta rays of radium are harmful to the tissues and are excluded by the use of a suitable filter, platinum being the one in common use. Radium is sealed up in hollow platinum needles usually 0·5 mm. thick. Radon is screened in a similar manner, the platinum surrounding a capillary glass tube which contains the gas.

There are several ways of using radium:

Surface application

(1) It may be applied on the surface against the skin. The radium is contained in needles which are attached to and held at a little distance from the skin by a sheet of Columbia paste, sponge rubber or other suitable material. This method, known as surface application, is not much used and is only advisable for surface growths and for treatment of secondary glands in the neck.

Interstitial implantation

(2) Interstitial implantation is the commonest method. Radium needles are put into the tissues. If the tumour is not more than one centimetre in thickness the needles are placed so that they lie immediately deep to it, and are about one and a half centimetres apart. With thicker tumours it is necessary to put some of the needles through the growth in order to irradiate the whole mass of malignant tissue. Dosage is largely a matter of experience but a rough rule which is of help is that one milligram of radium for five days should be used for each cubic centimetre of tissue.

'Bomb' or 'beam' treatment

(3) A large quantity of radium may be used at a distance; this method known as the 'bomb' or 'beam' treatment is now under trial. Quantities of radium varying from one to four grams have been used. The radium in a container with suitable screenage is held close to the patient's lesion for a certain number of hours a day. This method of application has brought about a great improvement in advanced and otherwise untreatable growths in the mouth and other regions. Some ulcerated growths have healed completely; it is, however, too early to give a final judgement on the merits of this method of treatment.

Radium is used as the method of choice in certain new growths which are operable. In other situations its use is confined either to inoperable growths or recurrences, or simply as a precautionary measure following excision.

Indications for radium treatment

A few examples of cancer for which radium treatment is the method of choice may be mentioned. For epithelioma of the lip, tongue and cervix uteri, and for rodent ulcer on the face, radium treatment is preferred to other methods by some surgeons. Although epitheliomas of the lip and tongue can often be completely eradicated by operation the consequent mutilation is disfiguring and speech is affected. When the same tumour is treated with radium, a soft, supple lip or a tongue of practically normal shape is in many cases left. An adequate number of radium or radon needles are placed in the tongue and kept there for about a week. There is a certain amount of reaction and consequent discomfort at first, but within a few days of removal of the needles the edge of the growth begins to diminish in size and gradually the ulcer heals. The maximum benefit is obtained in 6 to 8 weeks. Some epitheliomas are resistant to radium and excision may then be necessary.

Although radium gives good results with certain primary tumours, it does not usually do so with metastases to the lymph nodes.

This is true of the tongue, and although radium and X-rays have been tried in various ways, a complete block dissection of the lymphatics and glands and surrounding structures of the neck still remains the best treatment.

In other situations radium is frequently used for inoperable growths—cancers of the rectum, for example. When it is possible to remove a growth of the rectum by complete excision it is the method of choice, but when for any reason this cannot be done, radium may be used and in some cases has brought about a very striking improvement even causing the growth to disappear, at least for a time.

X-ray cancer

The association between X-rays and cancer is not merely one of treatment. As the result of repeated exposure the majority of the early X-ray workers developed on the hands dermatitis which was followed by epitheliomas necessitating amputation of fingers, hands or even arms. Since this danger was realized the hands and bodies of operators have been adequately protected. For many years the value of X-rays as a form of therapy has been realized and during the last ten years great improvements have been made both in the apparatus used and the technique employed. For treating cancer deep X-ray therapy is now mainly used and apparatus working at three hundred thousand volts has been extensively employed. Much higher voltages are now under trial.

Indications for X-ray treatment

X-ray treatment has a very wide field in the treatment of cancer, but its uses may be summarized in the four following headings:

(1) X-rays are used as the method of choice, in preference to radium or excision in certain situations.

(2) Adherent malignant growths after treatment by X-rays may diminish in size and become movable, making surgical extirpation possible and desirable.

(3) After removal of a tumour X-rays are used as a prophylactic against local recurrence.

(4) For inoperable growths X-rays are used to improve, if not to cure,

the condition, and as the only method of treatment available. But X-rays should not be used for the sake of 'doing something' in hopeless cases. They make the patient uncomfortable and perhaps by making his general condition worse allow the growth to progress more rapidly.

Choice of methods

The modern treatment of cancer in some of the commoner sites in the body will now be briefly mentioned.

The mouth

For the lip, floor of the mouth and tongue interstitial radium treatment for the primary growth with removal by dissection of the glands in the neck gives the best results; X-ray treatment is indicated for epitheliomas of the hard and soft palates.

Larynx

Intrinsic carcinoma of the larynx is radio-sensitive, and, if it cannot be removed surgically, should be treated by X-rays; the results are good. Extrinsic growths should be excised or treated with radium.

Lung and bronchus

Tumours of the lung and bronchus are comparatively common and appear to be increasing in frequency. The apparent increase may be due to improvements in diagnosis which the better use of X-rays has brought about. Treatment is difficult. In cases in which the tumour is recognized early and is definitely localized, it is sometimes possible to remove the growth by surgical procedures. In most cases, however, deep X-ray therapy is the only available method of treatment, and owing to the tendency of lung tumours to metastasize the results are seldom satisfactory.

Alimentary canal

For carcinoma of the oesophagus X-ray by Levitt's technique seems to give the best chance of cure, although encouraging results are sometimes obtained when growths of the lower end of the oesophagus are treated with radium. For the rest of the alimentary canal radio-therapy has little place and excision if possible should be employed; but for irremovable rectal growths radium often brings about a considerable improvement.

Skin

For carcinoma of the skin good results are obtained by excision or by either form of radio-therapy unless bone is involved. In this case radical excision followed by skin grafting is usually best.

Breast

For carcinoma of the breast a combination of excision and X-rays, or radium and excision should be used. For inoperable growths and recurrences on the chest X-rays may be used with hope of considerable improvement.

Uterus

In early cases of carcinoma of the cervix radium and X-rays give results as good as operation by the most experienced gynaecologists, and they are therefore generally preferred. Relief commonly, and cure occasionally, may be obtained even in advanced cases by radiation therapy. In carcinoma of the corpus operation is preferred in operable cases, and radiation measures are restricted to the advanced cases.

Round-celled sarcomas

Round-celled sarcomas arising in soft tissues have with any treatment a bad prognosis, but X-rays should be preferred to any other form of treatment; although the tumour sometimes regresses rapidly under this treatment, it usually recurs.

Bone

Amputation gives the best chance in treatment of sarcomas of bone.

X-ray treatment to the chest and stump may then be of some value as a prophylactic against recurrences.

Genito-urinary system

In the genito-urinary system tumours of the kidney, bladder, prostate and testicle should be removed. For irremovable vesical growths radium may be used with some success. X-rays sometimes bring about at least a temporary improvement in inoperable carcinoma of the prostate. Tumours of the testicle are very sensitive to X-rays and after orchidectomy a course of deep X-ray treatment should be given to the site and to the abdominal glands. Even palpable abdominal deposits may often disappear for some years.

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CANCRUM ORIS

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213.] This disease, known also as gangrenous stomatitis, noma or gangrene of the cheek, is fortunately rare at the present day. It is practically limited to children, especially between the ages of two and five, and the resulting extensive destruction of the face presents an unforgettable picture.

Aetiology

Little is known about the aetiology save that the malady usually follows a debilitating illness, being commonest as a sequel to measles or enteric fever. It has been reported after scarlet fever, pertussis, diphtheria, and dysentery. It is unusual for the less severe forms of stomatitis to develop into cancrum oris, and there is no evidence that it need follow mercurial stomatitis. Various micro-organisms have been found in the diseased tissue, chiefly the Vincent's spirillum and occasionally a true *Corynebacterium diphtheriae*. The condition never occurs in a healthy child. In the past epidemic outbreaks occurred in institutions for debilitated children.

Bacteriology

Clinical picture

The disorder is curiously more common among girls than boys. The early stages are comparatively trivial and, except for increased salivation and the appearance of a small blister with a congested margin on the inner surface of the cheek, there is little to indicate the serious nature of the malady.

An ulcer with a sloughing base speedily develops but, even at this stage, there is often little systemic disturbance and surprisingly little pain. The breath becomes extremely offensive and blood-stained debris is expectorated with the saliva. The ulceration spreads both in extent and in depth. The cheek and lip on the affected side become oedematous at first and later the cheek takes on a livid hue at the spot where necrosis eventually occurs. The disease is almost always unilateral. By this time the glands beneath the jaw have become enlarged and hard but not tender. The painless nature of the lesion is remarkable and the appetite is often retained after the ulcerative process has actually reached the gums or tongue. As the tissues of the cheek are destroyed, the general condition becomes worse. Fever, rapid pulse, anaemia, loss of appetite, diarrhoea and a septic broncho-pneumonia lead rapidly to the end. This whole process may take place within six to twenty-four hours.

The mortality rate is about 80 per cent, and only in the mildest cases does recovery occur. When the necrotic process is arrested healing takes place slowly with great scar formation, and as a result of this the mouth may be almost completely closed. In some epidemics other parts of the body (e.g. vulva) have been affected, and in rare instances the ulceration begins externally in the skin of the cheek (noma).

Diagnosis The condition when established is not easily mistaken for any other disease. The appearance of the early stages in the mouth may suggest diphtheria, but this infection is unlikely to attack the mouth unless the fauces are already involved and a swab will help diagnosis. From the livid colour of the skin, the oedema, and the central necrotic area anthrax may be suspected; but the odour of the breath is never so foul as in cancrum oris and, besides being rare in childhood, it begins on the cutaneous side of the cheek.

Treatment Prophylaxis is extremely important. Cleansing of the mouth during any infectious disease is now clearly recognized as an essential part of he nursing and since the introduction of modern antiseptic methods the malady has almost disappeared.

If gangrenous areas appear in the mouth treatment should be prompt and thorough, and consists in radical removal of the affected area usually by the thermocautery or diathermy knife. Some authorities have advised destruction of all the necrotic area in this way with application of the cautery to the edges two or three times a day. Arsenical applications have been much vaunted but have proved disappointing. A weak potassium permanganate mouth wash (e.g. 1 in 5,000) is probably best. The organic arsenical preparations have been tried internally but reports vary as to their value. The child's general strength must be improved as much as possible by feeding; copious drinks of glucose-lemonade are given and the inevitable anaemia is combated by blood transfusion.

Plastic repair If the necrotic process can be arrested, plastic operations can be performed later if required; no attempt should be made to do this for some time as recurrences have been reported. It is best to wait until the general condition of the child is restored to normal, probably six months, before undertaking local interference.

CANITIES

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214.] Canities may be congenital, but is more commonly acquired. Complete congenital canities is unusual, but it occurs in albinos accompanied by absence of pigment in the skin, iris, and choroid. The hair in albinism is white, or sometimes pale yellow, and is usually fine and silky. The skin of the body readily inflames on exposure to sunlight owing to the absence of pigment, and photophobia is common. Albinism is a Mendelian recessive character; it is discussed fully in Volume I, page 271.

Aetiology

Greyness or whiteness of the hair is the result of a physiological process and is a natural accompaniment of advancing years. It is due to a gradual failure of the pigment-forming powers of the body. The skin pigments or tans far less readily in the old than in the young. But individuals and families vary considerably in the age and the rapidity with which canities occurs. Generally there is a familial disposition. Very dark hair loses its pigment at an earlier age than blonde hair. All degrees of loss of colour are seen; at first only a few hairs in certain regions—especially the temporal—are affected, the so-called iron-grey hair, but gradually there is a progressive diminution of pigment till all the hair becomes grey and finally white. It is uncertain to what extent local disease of the scalp, e.g. pityriasis capitis, is a causal factor. It is thought by some to be associated with certain diatheses, e.g. the allergic. Greyness may or may not be associated with partial baldness.

Premature canities

Premature canities may be seen at an early age, even in young adults, and is usually unassociated with any disease, although mental strain, worry and overwork dispose to it. In some young people isolated tufts of white hairs occur in one or more areas long before the onset of physiological canities, and may be a manifestation of partial albinism. From time to time instances are reported of whitening of the hair in a few hours as the result of intense emotional strain; although some of these cases appear to be supported by reliable evidence, such accounts of sudden loss of pigment should be regarded with caution and even with suspicion. Vigulo-Lutati has described some cases of sudden whitening of the hair in soldiers during the Great War, and these would seem to be well substantiated.

Sometimes on inspecting the scalp it can be seen that the hairs, although coloured in the greater part of their lengths, are white near their roots, i.e. for an inch or more from the surface of the scalp. Such an appearance is evidence of the previous application of a hair dye, the white parts being the new growth since the last application of the dye.

Vitiligo

Localized canities is seen in vitiligo or leucodermia. In this remarkable condition depigmented areas of skin appear, each surrounded by a margin of hyperpigmentation; usually the areas are at first round, but by fusion large irregular portions of the skin may be affected. The lanugo hairs over such regions become white and patches of white hair may be seen on the head if areas of skin adjacent to the scalp are affected. After alopecia areata it is quite usual for the first growth of hair to be colourless, but in the course of time normal pigmentation of the hairs usually takes place.

'Ringed hairs' in which there are alternate rings of white and dark colour are sometimes seen in the scalp or moustache.

Rare instances have been recorded of the hair becoming white in winter and regaining its colour in the summer.

Prognosis

The prognosis in canities is not very satisfactory. Recovery of colour may be confidently predicted in the majority of the cases following alopecia areata and in some of the instances in which whitening has occurred as the result of illness or emotional strain.

Treatment

In treating this condition a comprehensive survey of all the body functions should be made and any deviations from the normal dealt with as far as possible. Small doses of thyroid gland are sometimes beneficial.

The use of dyes should be condemned; all are unsatisfactory and many are dangerous. It is true that dyes are used by many with impunity, but there is always a danger that sooner or later acute dermatitis may supervene. The dyes most satisfactory from the cosmetic point of view are those containing paraphenylene-diamine, but these above all are most likely to lead to acute inflammation; so dire are the consequences seen by the dermatologist that it is his duty to discountenance the use of dyes in any form.

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CARBON MONOXIDE POISONING

See TOXICOLOGY: HOMICIDAL, SUICIDAL, AND ACCIDENTAL POISONING

CARBUNCLE

See BOILS AND CARBUNCLES, p. 549

CARDIAC ASTHMA

See HEART DISEASES

CARDIAC FAILURE

See HEART DISEASES

CARDIACOS NEGROS

See ERYTHRAEMIA

CARDIOSPASM

See ACHALASIA, Vol. I, p. 116

CAROTID GLAND

See NECK: TUMOURS AND OTHER MORBID CONDITIONS

CARRIERS IN INFECTIVE DISEASE

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1.–DEFINITION

215.] By a carrier is generally meant a human being who, although not ill, is infected with and capable of disseminating the causal micro-organism or parasite of some disease. It is doubtful whether any carrier can really be considered perfectly healthy, but the term implies that the infection is unsuspected or not obvious and that any disablement is slight and does not prevent locomotion. It is hardly possible that a pathogenic bacterium, protozoon, or other parasite should not produce some local reaction of the tissues by its presence, life, growth, and multiplication in the body. The infective agents are often discharged in enormous numbers by carriers. On the other hand, infection may be present but the parasites not be distributed because the lesion is closed and the transfer of the disease thereby prevented; and in this case the host is not acting for the time being as a carrier.

From the practical point of view the exact state of health of the carrier is unimportant so long as he or she is able to behave in a fairly normal manner; but the risk to the community is much greater if ordinary association with carriers is not prevented, and their capacity for doing harm is much increased if they move from place to place.

2.–TYPICAL RELATIONS BETWEEN CARRIERS AND PARASITES

It has been pointed out and emphasized by Theobald Smith that successful parasitism, from the point of view of the invader, involves a mutual tolerance of the host and parasite, so that both survive with a minimum of inconvenience to either. This state of equilibrium, approaching symbiosis, is responsible for the more dangerous type of carriers. It appears to be the final stage in the evolution of successful parasitism; an earlier stage is seen in the latent infections, the '*infectiones inapparentes*' described by Nicolle in typhus fever.

Latent infections

It is believed that where typhus is endemic, some persons have very mild attacks and so maintain a reservoir of the rickettsias. In the somewhat similar disease trench fever, in which the causal rickettsia is also transmitted by lice, chronic infection may persist long after the symptoms have disappeared, so that lice feeding on the blood acquire the rickettsia and transmit the disease. The relation of inapparent infections to chronic carriers is illustrated by these two diseases.

Wild game as carriers

The chronic infection of wild game in Africa with *Trypanosoma brucei* appears to be a perfect example of a healthy carrier state from which the tsetse-fly transmits fatal disease to domesticated cattle and horses. It is noteworthy that in this and the similar symptomless infection of the rat with *T. lewisi*, resistance to fresh infection develops and persists after the protozoa have disappeared from the host. In human malaria, on the other hand, although chronic infection and an efficient carrier state may last a very long time, the health is usually impaired.

The fact that those in apparent health or only slightly indisposed could transmit to others acute diseases, such as diphtheria, scarlet fever and some other ailments, was recognized on clinical evidence before bacteriological proof was forthcoming, and the dissemination of diseases due to viruses, especially acute poliomyelitis and influenza, was accepted on epidemiological grounds before it was proved that healthy intermediaries harboured the virus.

The overwhelming evidence that carriers in the modern sense were commonly the chief effective distributing agents and served as foci for the origin of fresh outbreaks made a great change in the outlook of the epidemiologist, who formerly was driven to seek for the *materies morbi* in soils, marshes and effluvia.

Convalescent carriers

The search for, and discovery of, carriers was immensely stimulated by Frosch's suggestion (1903–4), and Drigalski's proof (1904), that the typhoid bacillus could be propagated in the human body and discharged long after recovery from enteric fever. These observations followed the proposition urged by Koch, that the ambulant convalescent was the chief disseminator of this disease.

Healthy carriers

The still earlier evidence (1889–90) that diphtheria bacilli might be found in the throat of a healthy person pointed in the same direction.

Koch's antityphoid campaign and Conradi's researches (1909), followed by similar work in Great Britain (by Ledingham) and elsewhere, and the recognition of paratyphoid carriers by Conradi (1906), established the predominating importance of carriers in the enteric group of diseases.

Bacteriological detection of carriers

The acknowledgement of the widespread role of carriers has followed improvements in methods of detection and recognition of the agents of disease. Some of the earlier observations were confused by the inability to distinguish the diphtheria bacillus from its congeners and to differentiate between the members of the salmonella group, which includes the paratyphoid and the 'food poisoning bacteria', *Salmonella enteritidis* of Gaertner and *S. aertrycke.* During the last twenty-five years there has been an ever-increasing multiplicity of demonstrations of the direct effect of carriers in many groups of diseases, and evidence has accumulated that during epidemics a large number of persons become infected without clinical manifestations.

These facts, taken together with a study of the distribution in nature of the germs pathogenic for man and animals, has irresistibly led to the view that most infective agents do not as a rule live and multiply saprophytically, but must be transferred directly, or with only a short interval in the outside world, from one living host to another.

Carriers of animal diseases

It is now hardly necessary to emphasize that the manner of spread of disease is very similar among all mammals and birds and that this likeness is especially well seen in man and the domesticated or tame animals in which the data have been most thoroughly studied. The importance of carriers has been recognized in tuberculosis and contagious abortion of cattle, glanders in horses, bacillary white diarrhoea in poultry, and psittacosis (a virus disease of parrakeets).

Human infection from lower animals

There are several well-known instances in which man is usually or exclusively infected from the lower animals—for example, glanders, undulant fever (which is probably always acquired from goats, cattle or sheep, usually by drinking raw milk) and psittacosis.

It is difficult or impossible to distinguish the means by which infections are spread from carriers and from actual cases of disease, and therefore the factors governing both must be considered together.

Classes of carriers

Human carriers have been divided into three classes:

(1) Precocious carriers who are infected although symptoms have not yet arisen. These are seldom detected and in most diseases are probably unimportant; with them may be grouped the large number of temporary carriers and subclinical cases which occur in many epidemics.

(2) Convalescent carriers who have recovered clinically but still harbour and excrete the infective organisms for a period which has arbitrarily been set at not more than three months.

(3) Chronic carriers, the *Dauerausscheider* of German writers, who persistently produce and discharge the germs of disease for many months or years. These occur in enteric fever, dysentery, diphtheria, and other infections without obvious disturbance of the health of the

carrier. This chronic state may be the sequel of an overt attack of disease, but sometimes cannot be connected with any definite previous illness.

From the public-health point of view, the members of the last category form the most important class of carriers as they may start outbreaks of disease without warning. Convalescent carriers may be equally dangerous, but the risk due to them can be avoided. The temporary carriers and latent cases are of great or even the chief importance in connexion with the rise and fall of epidemics.

This distinction of classes of carriers has been most often described in the enteric or intestinal group of diseases, but similar facts have been ascertained, or justifiably assumed, for many other diseases of man due to bacteria or viruses. In animals the state of health is seldom ascertained so carefully as in man, and consequently in them the boundary between the carrier state and chronic disease is more ill-defined.

Relation of carriers to epidemics

The number of carriers present in an outbreak of disease is very much influenced by crowding of the population. That a large number of carriers are present during some epidemics has been shown by repeated examination of the members of the community concerned, and the isolation of the causal organism, or by evidence derived from immunity reactions. This aspect of epidemic and endemic disease has been illuminated by experiments made with large numbers of mice by Topley and others. In herds of mice exposed to infection with *Salmonella aertrycke* the great majority of the population were infected at one time or another, judging from the post-mortem evidence, and in one experiment actually 71 per cent were found to have latent infections. The conditions of such an experimental epizootic do not correspond closely with those of human epidemics, but there is good reason to believe that during the prevalence of enteric fever a much larger proportion of the population is infected subclinically than actually suffers from definite attacks of the disease. In epidemics of cerebrospinal meningitis the carrier rate at one time in a community may be 20 to 30 per cent or more and the same is probably true of poliomyelitis.

Significance of carriers

Carriers take an important part in the transmission of disease in two ways: (1) as the link between two individuals in an outbreak or during endemic conditions, and (2) as originators of outbreaks in fresh areas, or previously infected areas after long intervals of freedom. In such cases the outbreak may be due to a carrier moving to another locality, or to his starting to discharge the parasite again after an intermission, or to his changing his occupation, or to his association with fresh susceptible individuals. Sometimes the new series of infections may result from an increase in the virulence of the parasite, but this cause has seldom, if ever, been established, although it is a very probable occurrence.

The part played in the spread of epidemics by carriers, including latent cases, as opposed to the sick persons, often preponderates but is variable. When the carriers are numerous, as in certain phases of epidemics of diphtheria and cerebrospinal fever, and when the patients are confined to bed or are isolated, the transmission is due almost entirely to carriers. Wickman showed that this was the method of spread of poliomyelitis by the fact that the cases of disease were often far apart and connected only by two or three intermediary links; later evidence has indicated widespread immunity in such a community. In other diseases, such as measles, in which the patient is often highly infective in the early stages, the infection is usually, if not always, spread directly by the sick person.

Carriers and vectors of protozoa disease

The protozoal diseases such as malaria, sleeping sickness, and trypanosomiasis of animals, in which the parasite is present in the circulating blood, are spread chiefly by carriers and individuals with chronic infections, but in these, unless the insect transmitter, or vector, is present, the carrier is not a danger. Movement of the mammalian carriers from one place to another where the essential species of insect is present, is liable to start a new outbreak. The insects may have long been present, but the disease absent because the mammalian carrier of the protozoon has not been introduced. The transport of malaria has often happened in this way, especially during military campaigns; and cattle disease, such as red-water which needs a tick for its transmission, has followed a similar course. The introduction of trench fever and typhus are other well-known calamities of war, when lice have been prevalent and only the carriers were needed to start the epidemic.

Vectors of parasites

The restriction of the term carrier to vertebrate hosts is not quite in accordance with general usage, since the insect or tick which transmits a disease is often spoken of as a carrier, and the part played is not so very dissimilar since the micro-organism usually multiplies in the arthropod host and may persist for the lifetime of the latter. The term vector is properly applied to such invertebrates and, although they may act as a reservoir of the infective agent for a time and may even survive during one winter, it is only in exceptional instances that the microbe is transmitted to their offspring through the egg and maintains a focus of infection for an indefinite period. Such a second cycle in the invertebrate may occur in ticks in which, for example, the rickettsia of the Rocky Mountain fever of rodents and man, and the piroplasm of red-water in cattle, are passed from one generation to another. In some diseases, such as tularaemia and some forms of typhus and leishmaniasis, the means by which the insect or tick has become infected may be obscured by the invertebrate host feeding on some unknown mammal or one of several species, for one or more generations; and in tularaemia there are several alternative vertebrate and invertebrate hosts.

Invertebrate vectors acting as intermediate hosts transmit parasites of very varied kinds, including helminths, and especially trematodes and the microfilarial larvae of nematodes; but the invertebrate vector is not so important a reservoir as the vertebrate host.

Porters of infection

For the sake of completeness a distinction must be pointed out between true vectors in which the parasite multiplies and persists, and 'porters' such as house flies, which only transport infective material from one host to another directly or indirectly, usually by feeding on excreta and conveying bacteria to food and milk on their feet and mouth parts, a frequent method of spreading cholera, enteric fever, and infantile diarrhoea.

Multiplication of bacteria outside the host

Although infection generally comes much more often from a living host than from dead fomites, there are two categories of pathogenic bacteria which commonly multiply or pass some time in the outside world before entering another host. The first of these includes some of the salmonella group which, unlike most pathogenic bacteria, multiply outside the body in food materials such as milk and meat. *B. typhosus* and *B. paratyphosus*, for instance, rapidly multiply in milk at a suitable temperature. Other members of the salmonella group, especially Gaertner's bacillus and *S. aertrycke*, when they cause so-called 'food poisoning' infections, have usually increased in numbers in the food before it is eaten. But these infections with *Salmonella* are derived without any long interval from human or animal carriers. *S. enteritidis* infections are sometimes due to the ingestion of milk or meat from infected cattle or the eggs of infected ducks or fowls; or human carriers may infect the food; *S. aertrycke* infection is probably more often due to contamination of food with the excreta of rats which are often carriers of this organism.

Survival of bacteria outside the host

The other category of parasites not directly derived from the vertebrate host consists of several diverse kinds of organisms which survive in the outside world for long periods by means of a resistant stage in their life history. The sporing pathogenic bacteria are mostly anaerobic; they are natural inhabitants of the intestine of animals or man who act as carriers and usually do not show any sign of disease. They also live and multiply outside the body in dung. The majority constitute the gas-gangrene group of bacilli and infect man and animals through wounds; but they may, under suitable conditions, also cause other diseases, such as lamb dysentery and braxy of sheep, when they have entered the body by ingestion. These bacilli may multiply freely in the diseased tissues during life but more especially after death. They cause death by the toxins which they produce in the intestinal canal or in the tissues. Outside the body they form spores which survive in the soil for months or years. The tetanus bacillus is also an inhabitant of the intestine, especially of the horse, which is believed to be the chief carrier. It lives in dung and garden soil, and infection takes place by means of spores which infect through wounds, but multiplication in the tissues is very scanty, and the symptoms are due to toxin absorbed from the local lesion. Human intestinal carriers are also known to occur.

Another sporing bacillus which gains access to the body through wounds is the *B. anthracis*. It is aerobic and multiplies freely in the blood and tissues of infected man and animals, but not in the outside world. It causes acute disease which is usually fatal and does not give rise to carriers. It has therefore perhaps a unique life history for a bacterial parasite. Its success as a parasite is due to survival in the sporing stage after the death of the host. The spores are only formed after death and are then present in very large numbers in the blood. Human infection takes place from spores on contaminated hides, hair, blood or bones of animals usually long after the death of the former host, but occasionally from carcases soon after death, and not from man to man. The lower animals are infected as a rule by spores in the soil which has been infected by blood.

Survival of protozoa and worms

Other parasites of very different kinds, such as amoebae and many helminths, have a resting stage and survive outside the body in soil contaminated with faeces. They do not as a rule cause rapidly fatal disease, and the host may live for a very long time and act as a carrier with an intestinal infection. The cysts of *Entamoeba histolytica* and the eggs of *Ascaris lumbricoides* and many other worms are very resistant in the soil, infecting new hosts when ingested with food.

3.–DETECTION, CURE AND CARE OF CARRIERS

Detection

The diagnosis of carriers obviously depends on the exact nature of the infection, and the technique is different for every kind of parasite. The discovery of the infection is comparatively easy if parasitic bacteria, helminth eggs in the excreta, or the protozoa in the blood, are numerous and constantly present, but this is by no means always the case. Various methods are used for the detection of bacteria, e.g. growth on selective culture media; and it is often necessary to concentrate the eggs of worms by centrifuging.

Chronic carriers of intestinal bacteria often discharge the germs intermittently, and long periods of weeks or months may elapse during which it is impossible to find them in the faeces. Repeated examinations may therefore be necessary to detect the parasites; similar intermissions occur in carriers of bacteria in the throat and nose. Examination of the blood serum for agglutinins or other antibodies, and tests for allergic reactions may be valuable guides to the existence of carriers, and are particularly helpful when it is necessary to examine a large number of persons, such as the members of a school, regiment, or asylum in order to obtain an indication of those to whom search should be especially directed. The demonstration of the parasite itself, however, must be the final criterion of infection.

Cure

The cure of carriers is often extremely difficult or even impossible. Although drugs are frequently effective in dealing with helminth or protozoal infections, bacterial carriers often defy all measures, and vaccines and chemotherapy have not proved of much value. On the other hand, surgical treatment may be successful in some cases. Typhoid carriers are sometimes cured by removal of the gall-bladder, when cholecystitis and gall-stones render the operation desirable, but no useful treatment of urinary typhoid carriers has been discovered.

Persistent sojourn of diphtheria bacilli in the throat can frequently be ended by extirpation of the tonsils and adenoids.

Care

The supervision of chronic carriers is a very serious and difficult problem, and each case requires individual consideration, since the occupation, habits, and intelligence of the carrier should be taken into account.

Isolation

Strict isolation of carriers is seldom practicable except in the case of convalescents whose isolation after infective disease can often be prolonged until the discharge of the disease germ has ceased. The co-operation of the carrier must always be enlisted as far as possible, and, although certain rules of conduct can be laid down, common-sense attentions to details of habits and behaviour must be relied on for the most part. It is remarkable and not always easily explained why some carriers, both of intestinal and of respiratory infections, are far more efficient, i.e. dangerous, than others, repeated outbreaks or fresh cases of disease being often attributable to comparatively few individual carriers. This characteristic may no doubt generally be explained by the habits of the individual, or by the number and virulence of the germs excreted.

Those who distribute parasitic bacteria or viruses by droplets with the breath must, as far as possible, be kept away from susceptible persons, especially from schools, and should not frequent crowded places. The risk of receiving infection is rapidly decreased by distance and a reasonable separation of beds in a dormitory is a particularly helpful protective measure. Since an increase in the distance of the mouth of one individual from that of another is the aim in spacing out the beds, the effect is much increased by arranging the beds head to foot. If those with nose and throat infections did not approach within three feet of others, especially during conversation, and also used some covering such as a hand or a pocket handkerchief during coughing and sneezing, the amount of transference of infection would be enormously diminished. Droplets may also convey infection to wounds, and may directly or indirectly contaminate food and especially milk.

Personal hygiene

Carriers who excrete bacteria or other parasites with the faeces or urine should be scrupulously cleanly in their person and clothing, and especially their hands, and should not be employed in handling or preparing food. Their excreta should be disinfected, and when contamination of drinking water by carriers is possible it must be chlorinated or boiled. Furthermore, carriers should not engage in dairy work, and, as unwitting carriers may infect milk, all those who are employed in milking or in the preparation or distribution of milk should be particularly careful and clean in person and habits.

Isolation

Where strict discipline is possible as in the Navy, Army or Schools, the isolation or exclusion of certain classes of carriers is desirable, but the measures should be in reasonable proportion to the numbers of carriers detected and the state of immunity of the population concerned. If only a few carriers can be found and if there is reason to believe that the introduction of infection is recent, no doubt isolation is desirable, but in many outbreaks, such as those of cerebrospinal fever, dysentery and cholera, a very large proportion of the community may be carriers and isolation impossible; in some schools where diphtheria has become endemic the proportion of carriers is so high and the number of immune children so large that isolation of carriers would be futile, but Schick testing and the segregation and artificial immunization of the non-immunes is desirable. On the other hand, the introduction of a carrier into a non-immune population or household, or of susceptible children into a school containing carriers, may have serious results.

4.–SITES OF INFECTION IN CARRIERS

In chronic typhoid and paratyphoid carriers the most important sites of infection are the mucous membrane of the gall-bladder and biliary ducts, or the pelvis of the kidney. Areas of chronic inflammation are found in the gall-bladder, which often contains gall-stones consisting of bile pigment with living bacilli in their interior. Typhoid carriers are sometimes liable to recurrent attacks of slight fever and intestinal disturbance. Cholecystitis may also occur in carriers of Gaertner's bacillus.

In chronic carriers of streptococci and of *C. diphtheriae* foci of infection and inflammation have been found in the mucous membrane of the tonsils, and it is a fair assumption that similar foci are present in carriers of other pathogenic bacteria, and that the state of the tissues merges into that recognized in chronic disease, although no doubt such bacteria may live on the surface of the mucous membranes for a short time. Malarial carriers with splenic enlargement are more obviously cases of the disease.

5.–CARRIERS IN SPECIAL DISEASES

Although a comprehensive account of carriers in individual diseases cannot be attempted, a short space may be devoted to some features of carriers of certain infections in which they have been specially studied.

Cholera

Carriers of cholera are very numerous in epidemics and many of them never contract the disease, although others may succumb later. Many carriers continue to excrete the vibrios for a considerable time after recovery, sometimes for two months, but rarely for more than 20 or 30 days. Many of the statistics of carriers are vitiated by difficulties in identifying the true cholera vibrio. The criteria of diagnosis are now better established and with care the organisms can be recognized by cultural tests and a good agglutinating serum, although more than one serological type of cholera vibrio probably exists and non-pathogenic vibrios are common. Drinking water is the common vehicle for transmission, but it is probably not long a 'reservoir' of infection unless it is frequently polluted. Routine bacterial examination of immigrants by means of rectal swabs has been practised on a large scale in New York, but reliance must usually be placed on isolating the sick and known convalescents, and treating the water-supply.

Bacillary dysentery

Carriers of bacillary dysentery are often very numerous, especially in hot countries, and in temperate climates in asylums or in crowded areas where sanitation is defective. There is usually definite slight localized inflammation of the large intestine. The discharge of bacteria is apt to be very irregular. The carriers may recover, or the disease may be progressive. The bacilli are seldom found in the stools unless mucus is present.

Amoebic dysentery

Carriers of amoebic dysentery no doubt always suffer from a more or less localized disease; slight ulceration in the upper part of the colon is often present without symptoms. Cysts may be discharged intermittently for years, but the disease is often curable by drugs.

Cerebrospinal fever

An epidemic of cerebrospinal fever consists of a large number of cases of persons whose nasopharynx is infected with the meningococcus. These carriers pass the infection from one to another with the breath. Occasionally the meningococcus invades the blood and it may invade the cerebrospinal system and set up meningitis as a complication, but as a rule only one or two cases of meningitis occur among a large number—20 to 100—of carriers. At the beginning of an epidemic, and probably often before a case of meningitis has occurred, the carrier rate begins to rise above 2 to 5 per cent, which may be considered normal. During the War it was shown that in certain crowded barracks the spread of infection in the sleeping quarters was stopped by spacing out the beds. When the carrier rate rose to 30 per cent cases of meningitis appeared. It has, however, been found that the carrier rate may sometimes reach 100 per cent without the occurrence of meningitis. Chronic carriers of the meningococcus may remain infected for many months, but more commonly the infection does not last more than 2 or 3 weeks. Sporadic cases of meningitis are no doubt due to human carriers, but this is difficult to prove.

Diphtheria

In diphtheria epidemics 15 per cent of contacts are often found by examination of throat and nose swabs to be carriers, but only 0·2 to 0·6 per cent of non-contacts; the latter proportion is common in the general population. Although the diphtheria bacillus present in carriers is usually virulent, i.e. toxigenic, it may be non-virulent, and since it is doubtful whether the latter ever becomes virulent it is customary to treat it as harmless.

Dudley, who for several years made a very thorough study of epidemic and endemic diphtheria in a school, recorded the intricate relations of cases of sore-throat, carriers and immunity. During one period he found that on an average 6·7 per cent were carriers, but seven or eight swabbings during the year showed that 40 per cent were carriers at one time or another. The bacilli were not always found in the same persons; some ceased to carry and were later re-infected. The carriers gradually acquired immunity to the Schick test. Further evidence of the high proportion of infections with or without sore throats was given by the fact that 85 to 100 per cent of boys in one part of the school were found to be immune to the Schick test. Schick immunity did not prevent an immune person from carrying virulent bacilli.

Streptococcus infections

Streptococci pathogenic for man are often present in the throat and nose without producing any symptoms. Carriers may remain infective for many weeks or months. The detection and diagnosis of pathogenic types is difficult and demands a number of special diagnostic sera (agglutinating and precipitating) and special technique. Infection of the puerperal uterus and of wounds is no doubt often caused by carriers, either directly by droplets from the mouth and nose or indirectly by organisms on the hands: the streptococci may be derived from the patient's own throat, for example in puerperal fever. A milker who is a carrier may directly infect milk from his throat or nose, or may set up mastitis in a cow with the result that enormous numbers of virulent streptococci pass into the milk, causing severe epidemics of sore-throat among those who drink it. But the common mastitis of cows is not due to a streptococcus pathogenic for man. The precautions needed are those mentioned on page 762 and boiling or pasteurization of all milk.

Whooping-cough

The bacterium of whooping-cough has been isolated from droplets discharged in coughing in 75 per cent of cases in the early stages, and in 9 per cent examined as late as the fifth week. Since this micro-organism is not very resistant outside the body, and has not been found after a few days in dried mucus, it is probable that human carriers are the source of infection in new outbreaks, but they have so far not been described.

Tuberculosis

Chronic cases of pulmonary tuberculosis discharging bacilli in the sputum frequently pass undiagnosed, for the patients may not be seriously ill. They are very potent disseminators of infection and are in effect human carriers. Tuberculous cattle are also often unrecognized and constitute a very serious source of human infection with the bovine type of bacillus through their milk. Segregation, whenever possible, is the best method of preventing human carriers from spreading infection. The risk of infection with the bovine type is avoided by pasteurizing or by boiling the milk. The eradication of tuberculosis from dairy herds is an agricultural matter which has made only slow progress in the United Kingdom but which has been achieved more successfully in other parts of the Empire.

Gonorrhoeal and staphylococcal infections

Chronic carriers of many bacterial diseases, such as gonorrhoeal and staphylococcal infections, are numerous, but are not generally distinguished from mild chronic cases of disease. They are, however, of great importance, especially gonococcal carriers who frequently transmit infection after supposed cure: the infection is commonly in the prostate in men and the cervix uteri in women. They can sometimes be cured by persistent treatment. The gonococcus is strictly parasitic so that the spread of the disease is only by means of cases and carriers.

Diseases due to viruses

Carriers of viruses are known to occur on clinical evidence, and their occurrence has been confirmed in the form of influenza which has been studied by Laidlaw, and in poliomyelitis, by finding that the blood of persons who have not shown symptoms has an antiviral action.

Helminths

Considered in regard to the spread of infection by human carriers parasitic helminths fall into two main groups: (1) those in which infection is spread by the ova of the adult worm which are passed out of the body of the carrier with the faeces or urine, and (2) those giving rise to microfilarial larvae which enter the circulating blood and are taken up by a blood-sucking insect. The former group comprises tape-worms, round worms (e.g. ascaris and hookworm), and trematodes (e.g., liver flukes and the schistosome of bilharziasis). The number of eggs discharged by parasitic worms may be enormous. A tape-worm may produce thousands of fertilized eggs—*Ascaris lumbricoides* 200,000, and *Schistosoma japonicum* several hundreds daily.

With few exceptions, the adult stage of each species or race of helminth is sharply restricted to one species of vertebrate. Unlike bacteria, helminths in the adult stage cannot multiply in the host, but can only produce eggs or larvae; re-infection is therefore needed to maintain the presence of the parasite after the worm dies or is displaced as the result of treatment. Some helminths, however, are very long-lived. *Taenia solium* may live for 25 years; hookworms are said to be naturally eliminated from the intestine in 5 or 6 years if there is no re-infection.

There are great differences in the fate of eggs of different kinds of worms outside the body of the host. The eggs of a tape-worm, if ingested, may infect the intermediate host as soon as they are excreted. Ascaris eggs require a few days to mature in the soil before they can re-infect the same or another host; they may be viable after a period of 5 or 6 years. Hookworm eggs cannot lead to infection until the larvae have hatched out and developed sufficiently to penetrate the skin of the new human host; the larvae may live in the soil 15 weeks; *Schistosoma* eggs soon hatch and the larva requires its invertebrate host.

The prophylaxis against infestation by these worms, the eggs or larvae of which infect man, consists chiefly in proper disposal of excreta, avoidance of contamination of food and water, or of contact of the skin with infected soil and water, and in some cases treatment of the carrier with drugs. The stage in the life of a tape-worm which lives in the flesh of animals used as food must be killed by cooking.

The Nematode, *Trichinella spiralis*, becomes encysted in the muscles of several species of mammals, especially pigs and rats, in the worm stage, in which it is infective if the meat is eaten uncooked. Human beings do not act as carriers, a part which is chiefly played by rats. The carriers of blood-trematodes and microfilariae may to some extent be made less harmful by measures directed against the invertebrate intermediate hosts, molluscs or mosquitoes.

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CARUNCLE, URETHRAL

See VULVA AND VAGINA DISEASES

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See EPILEPSY

END OF VOL. II

NOTE

An exhaustive analytical index to the *British Encyclopaedia of Medical Practice* will be published on completion of the work. In the meantime, each individual title is separately indexed in the volume to which it belongs, and there are additional references and cross-references to assist the reader in finding whatever information he may require as easily and quickly as possible.

The entries in black type correspond with the individual titles; those in large Roman capitals indicate the additional references and cross-references.

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